Health Consultation

COEUR D'ALENE RIVER BASIN

Evaluation of Metals
in
Bullhead, Bass, and Kokanee from Lake Coeur d'Alene

COEUR D'ALENE, KOOTENAI COUNTY, IDAHO

EPA FACILITY ID: IDD048340921

Prepared by

The Agency for Toxic Substances and Disease Registry
and
The Idaho Division of Health

Table of Contents

List of Appendices

Table of Contents

List of Figures

List of Tables

Acknowledgments

The Agency for Toxic Substances and Disease Registry and the Idaho State Department of Health and Welfare extend their appreciation to the following individuals for their assistance with preparing this document:

USEPA
Marc Stifelman and Anne Dailey, Region X, Seattle, Washington.

ATSDR
Ms. Ann E. Bradley, Ms. AnneMarie DePasquale, Dr. Jo Ann Freedman, Mr. Richard Kauffman and Dr. Sven Rodenbeck

Foreword

The Agency for Toxic Substances and Disease Registry (ATSDR) jointly prepared this public health consultation with the State of Idaho, Idaho Department of Health and Welfare, Idaho Division of Health (IDOH). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous waste. This health consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The health consultation is an approach used by ATSDR and IDOH to respond to requests from concerned residents for health information on hazardous substances in the environment. The health consultation process evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health.

This health consultation evaluates the metals data reported for fish samples collected in 2002. Analysis of metals in these samples was completed in early 2003 and final results reported in May of 2003. After reviewing the data in cooperation with multiple state and federal agencies, the State of Idaho and the Coeur d’Alene Tribe jointly issued a fish consumption advisory for Lake Coeur d’Alene in June 2003. ATSDR issued a letter of support for that advisory in June 2003. This consult documents our review and evaluation of the metals data used for the fish consumption advisory.

Purpose

The 2001 Human Health Risk Assessment for the Coeur d'Alene Basin indicated that more information was needed about fish in Lake Coeur d'Alene (TerraGraphics. 2001). The Coeur d'Alene Tribe and a collaborative inter-agency team agreed. As a result, these groups cooperatively conducted a study to determine the contaminant levels in fish from Lake Coeur d'Alene. The Agency for Toxic Substances and Disease Registry (ATSDR) and the Idaho Department of Health and Welfare, Idaho Division of Health (IDOH) were asked to review the data from this study and evaluate the potential health risks for tribal and recreational fishers that may result from consumption of three fish species found in Lake Coeur d'Alene.

Fish were collected in May and August 2002, and analyzed for 18 metals (Table1). Fish were collected at about the same time of year, and in areas used by tribal and recreational fishers. Fillet and gutted whole carcass samples were selected to represent the two major portion types used by both subsistence and sport/recreational fishers. Based on extensive discussions about use by tribal and sport/recreational fishers, ecological importance, relevance to other species, and patterns of exposure to contaminants, the three fish species selected were bass (mostly largemouth bass, *Micropterus salmoides*), bullhead (mostly brown bullhead, *Ictalurus nebulosus*), and kokanee (*Oncorhynchus nerka*). This health consultation evaluates the potential for adverse health effects associated with consuming these fish species.

Table 1. Eighteen metals analyzed in Coeur d'Alene Fish Samples (USEPA 2003).

Antimony (Sb)	Cobalt (Co)	Nickel (Ni)
Arsenic (As)	Copper (Cu)	Selenium (Se)
Barium (Ba)	Lead (Pb)	Silver (Ag)
Beryllium (Be)	Mercury (Hg)	Thallium (Tl)
Cadmium (Cd)	Manganese (Mn)	Vanadium (V)
Chromium (Cr)	Molybdenum (Mo)	Zinc (Zn)

Project Team

To conduct this evaluation, ATSDR and IDOH worked jointly with a collaborative inter-agency group to develop and implement the Lake Coeur d'Alene Fish Investigation. The investigation plan was prepared by the U.S. Environmental Protection Agency (USEPA 2002a) and approved by IDOH, ATSDR, USEPA Region 10, the Coeur d'Alene Tribe, Idaho Department of Fish and Game (IDFG), Idaho Department of Environmental Quality (IDEQ) and the U.S. Fish and Wildlife Service. The approval signatures on the sampling plan indicated that the entities participated in the development of the plan and believed it targeted the appropriate species and locations within Lake Coeur d'Alene to assess human health implications of consuming fish from the lake.

Background and Statement of Issues

Historical mining practices in the Coeur d'Alene Basin have resulted in contamination of soil, sediment, surface water, and groundwater. Currently, substantial portions of the Coeur d'Alene

Basin contain elevated concentrations of contaminants that are hazardous both to humans and to plants and animals (collectively termed ecological receptors). To evaluate and address the effects of mining contamination in the Basin, USEPA conducted a remedial investigation and feasibility study (URS Greiner and CH2M Hill 2001a, 2001b) and issued a Proposed Plan (USEPA 2001b) for cleanup of the Basin in October 2001. Following evaluation of public comments, USEPA issued a Record of Decision (ROD) in September of 2002 (USEPA 2002b).

The Bunker Hill Mining and Metallurgical Complex Operable Unit 3 (Coeur d'Alene Basin) ROD noted that questions about potential risks from eating whole fish or fillets from Lake Coeur d'Alene needs further evaluation (USEPA 2002b). Previous evaluations of fish tissue from Lake Coeur D'Alene have not included whole fish, and only limited numbers of fillets have been sampled. As a result, some uncertainty exists about the risks from eating fish caught in Lake Coeur d'Alene. The ROD also noted that collaborative fish investigations are being implemented to address data gaps regarding fish in Lake Coeur d'Alene.

In support of the ROD, human health (TerraGraphics 2001; CH2M Hill and URS Greiner 2001) and ecological (CH2M Hill and URS Greiner 2001) risk assessments were completed as part of the remedial investigation/feasibility study. The primary metals of concern identified include lead and arsenic for human health, and cadmium, lead, and zinc for ecological receptors. The human health risk assessment concluded that available data on contaminant concentrations in fish in Lake Coeur d'Alene are insufficient to quantify potential risks (TerraGraphics 2001).

The uncertainty section of the human health risk assessment indicated that potential exposure to contaminants from consumption of fish taken from Lake Coeur d'Alene has not been quantified. While substantial fillet data for three species are available for the lateral lakes, these data do not accurately represent risks for persons practicing a subsistence lifestyle in which other tissues, organs, or whole fish are consumed. Metal concentrations in fillets tend to be lower than metal concentrations in other fish organs or in whole body fish. Use of fillet data typically under-estimate risks for a subsistence lifestyle (TerraGraphics 2001).

Available fillet data for the lateral lakes was obtained from specimens too small for quantifying human health risks from consuming fish from Lake Coeur d'Alene. The species collected in the lateral lakes were not considered to be sufficiently representative for quantifying human health risks from Lake Coeur d'Alene fish. While risks were not found for sport/recreational fishers in the lateral lakes, their risks from consuming Lake Coeur d'Alene species could not be quantified using the existing data (TerraGraphics 2001). Nor do the lateral lakes data address concerns about subsistence consumption of fish from Lake Coeur d'Alene.

In addition to information provided in the human health risk assessment, the Coeur d'Alene Tribe has also identified the lack of data on fish in Lake Coeur d'Alene as a data gap (Coeur d'Alene Tribe 2001). The tribe submitted a preliminary fish sampling plan to EPA, portions of which were incorporated in the Fish Investigation Plan (USEPA 2002a).

ATSDR has examined lead issues in and around Lake Coeur d'Alene since 1989. Issues have included the relationship of lead and cadmium levels with fish consumption (ATSR 1989), risk factors for elevated blood lead levels in children (ATSDR 1995), health effects in female former smelter workers (ATSDR 1997a), and lead exposures in current and previous residents (ATSDR 1997b). ATSDR has evaluated metals in fish from the lateral chain lakes (ATSDR 1998) and in soils of residential properties in the panhandle counties of Benewah, Kootenai and Shoshone (ATSDR 2000a). ATSDR also reviewed a preliminary fish sampling plan (Coeur d'Alene Tribe 2001) and the Fish Investigation Plan prepared by USEPA (2002a).

Fish Sampling

Collection of fish from Lake Coeur d'Alene was performed in accordance with the Fish Investigation Plan (USEPA 2002a). This plan was collaboratively developed and detailed the protocol to be followed during collection of fish from the lake, shore processing of fish, and processing of fish samples at the laboratories.

The three species selected for capture and analysis were kokanee (*Oncorhynchus nerka*), largemouth bass (*Micropterus salmoides*), and bullheads (*Ictalurus* sp.) Based on input from IDFG, ATSDR, and others, these species were targeted for this investigation because of their use by both tribal and sport/recreational fishers. Tribal subsistence fishers extensively consume all three species, and a sport/recreational fishery exists for all three species. These three species are also of ecological importance to the Lake Coeur d'Alene fishery. They encompass a variety of feeding habits and home ranges, thus likely have different exposure patterns to contaminants.

Kokanee primarily feed on plankton found in the water column and range throughout the lake. The large home range of kokanee means that they should be good integrators of contaminant concentrations throughout Lake Coeur d'Alene. Largemouth and smallmouth bass are predatory on other fish, and have relatively small home ranges compared to kokanee. Bass should be more indicative of contaminants in localized areas of the lake. Bullhead species are mostly bottom feeders, usually associated closely with bottom sediments, and are not considered highly mobile. They should also help identify sediment-associated contaminants in localized areas of the lake.

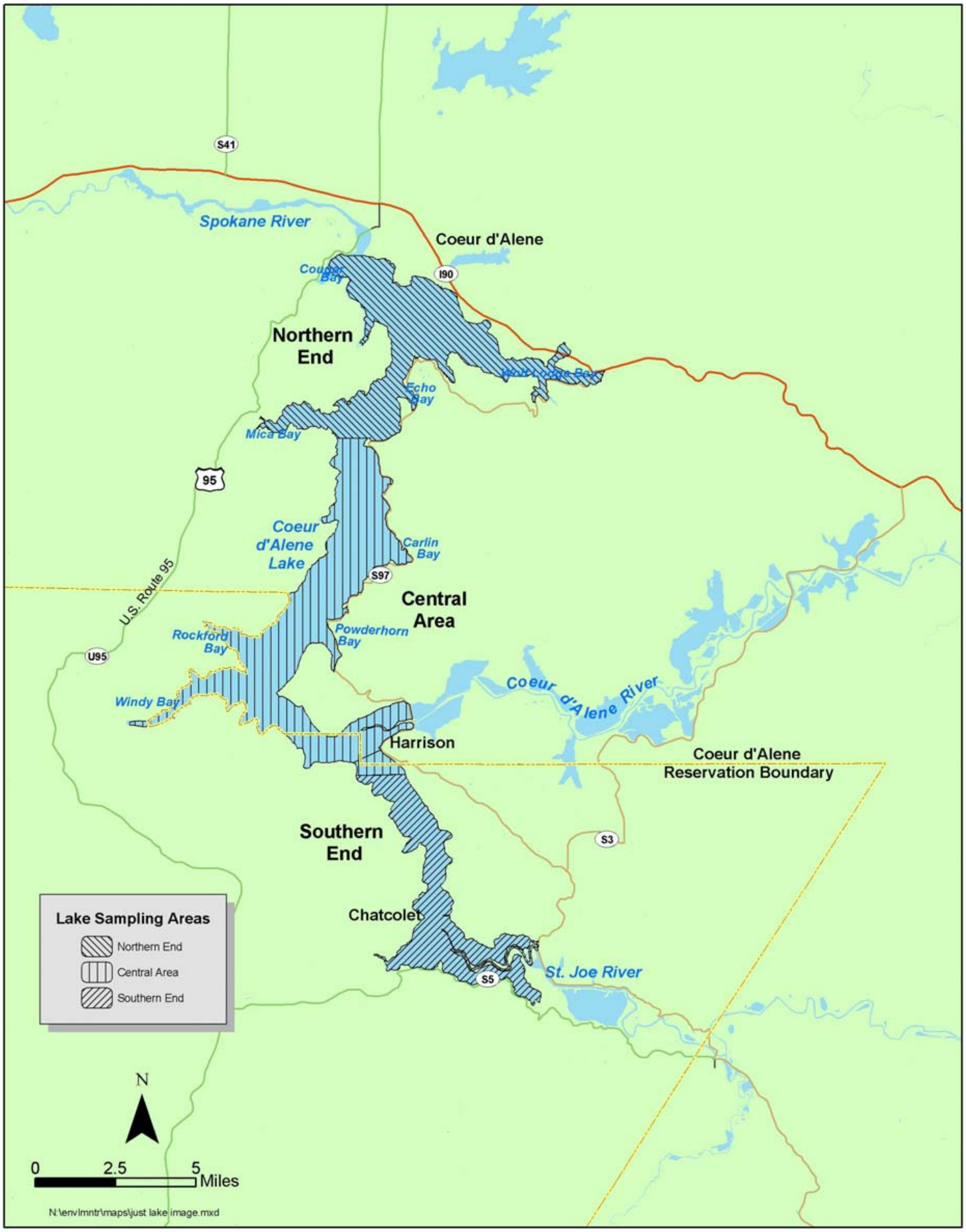
Sampling locations on the lake are shown in Figure 1. The three specific Lake Coeur d'Alene locations targeted for fish sampling in this effort were:

Northern end of lake (Mica Bay to Wolf Lodge Bay)
Central basin (mouth of Coeur d'Alene River north to Driftwood Point)
Southern basin (lake areas at least 1 mile south of the mouth of the Coeur d'Alene River)

Recreational and subsistence fish consumers use all three sampling locations. These locations also provide a geographically balanced sampling of the lake. Statistically significant sample sets of bullhead and bass were collected from all three locations. Because of the difficulty in collecting suitable numbers of kokanee from all three sampling locations, the lake was treated as a single sampling station for this species (USEPA 2003).

The two sample types obtained were gutted carcass and fillet. For gutted carcass samples, the caudal (tail) fin, gills, and guts, with the exception of the kidney, were removed. Gutted, whole-fish carcass samples were collected to represent the most common preparation method for fish which are smoked, canned, or used in soups and stews. Fillet samples were collected to represent a portion commonly consumed by sport, recreational and tribal fish consumers.

Figure 1. Lake Coeur d'Alene



Estimating Exposure Doses

One of the most important steps in assessing exposure to contaminants in the environment is to estimate the amount of a chemical to which people could be exposed (ATSDR 1992). For non-cancer health concerns, this is typically done by using the building blocks shown in the following calculation:

$$\textit{Estimated Exposure Dose (EED)} = \frac{\textit{Contaminant Concentration (CC)} \times \textit{Ingestion Rate (IR)} \times \textit{Annual Exposure Factor (AEF)} \times \textit{Absorption Factor (AF)}}{\textit{Body Weight (BW)}}$$

The estimated exposure dose (EED) may also be referred to as the annual exposure dose, and is calculated from available site specific information. In this health consultation, contaminant concentration (CC) refers to the metal concentrations reported for fish samples from Lake Coeur d'Alene by USEPA (2003).

The amount of fish that people eat is referred to as ingestion rate (IR) and may also be called consumption rate. Frequency and duration of exposure on a yearly basis are expressed as an annual exposure factor (AEF) to make calculations easier. The amount of a specific metal that is absorbed by people eating fish is estimated by using an absorption factor (AF). Estimated body weight (BW) for people consuming fish is the denominator of the equation.

The basic formula above is used to estimate the exposure dose for non-carcinogenic effects. For assessing cancer, the lifetime excess cancer risk calculation assumes a 70 year exposure period and is calculated as follows:

$$\textit{Estimated Annual Exposure Dose (mg/kg/day)} \times \textit{Cancer Slope Factor (mg/kg/day}^{-1}\textit{)}$$

Excess cancer risk for an exposure less than an entire lifetime is calculated using the following equation:

$$\textit{(Estimated Annual Exposure Dose} \times \textit{Cancer Slope Factor)} \times \frac{\textit{No. of Years Exposed}}{\textit{70 year lifetime}}$$

A typical less than lifetime exposure period is the residence time in the community where the exposure occurred. Two residence times typically used are 30 years for maximum time at one residence and 9 years for the median time at one residence (USEPA 1997).

Metal Concentrations in Fish

Eighteen metals (Table 1) were analyzed in three fish species collected from Lake Coeur d'Alene by USEPA (2003). Bullhead specimens were collected from all three sampling areas. The highest average values for arsenic and lead were found in the bullhead gutted carcass samples from the center lake sampling area (Table 2).

Bass specimens were collected from all three sampling areas. Results for bass gutted carcass samples were reported from all three lake sampling areas. Bass fillet samples were collected only in the center lake sampling area. The highest average mercury concentration (0.188 ppm) reported by USEPA (2003) was found in bass fillets (Table 2).

A limited number of kokanee samples were collected. Because of the highly mobile nature of kokanee, sample results were not divided by lake area. A lake-wide average was calculated for gutted carcass and fillet samples.

Average concentrations for arsenic, cadmium, lead, and mercury are shown in Table 2. Included are average concentrations for the three lake sampling areas shown in Figure 1 (north, center and south), the overall average for each fish species analyzed, and an estimated average for each metal by sample type (gutted carcass and fillet). Metal concentrations were typically higher in gutted carcass samples than in fillets with the exception of mercury (Table 2). Appendix A and B both show additional data for As, Cd, Pb and Hg. Other metals are summarized in Appendix C.

For our initial evaluation, the highest concentration for each metal reported by USEPA (2003) was used to determine worst case exposure conditions. If this indicated that no problems were likely from exposure to a specific metal, then that metal was ruled out as a contaminant of concern and not evaluated further. If our worst case scenario evaluation indicated a potential problem, then further, more detailed evaluations were done and the maximum average concentration was used.

Table 2. Summary of average arsenic, cadmium, lead and mercury results (mg/kg, wet weight) for fish samples from Lake Coeur d’Alene (USEPA 2003).

	Gutted Carcass Samples				Fillet Samples			
Fish Species and Sampling Location	Arsenic (As)	Cadmium (Cd)	Lead (Pb)	Mercury (Hg)	Arsenic	Cadmium	Lead	Mercury
Bass—North	0.126	0.021	0.156	0.174	-	-	-	-
Center	0.115	0.008	0.197	0.171	0.064	0.015	0.020	0.188
South	0.146	0.015	0.034	0.111	-	-	-	-
Lake Average	**0.129**	**0.015**	**0.129**	**0.152**	**0.064**	**0.015**	**0.020**	**0.188**
Kokanee (Entire Lake)	0.145	0.139	0.115	0.075	0.083	0.018	0.020	0.092
Bullheads--North	0.072	0.034	1.42	0.028	0.024	0.006	0.029	0.038
Center	0.218	0.077	3.85	0.045	0.116	0.016	0.232	0.065
South	0.05	0.020	0.479	0.052	0.028	0.005	0.026	0.063
Lake Average	**0.113**	**0.044**	**1.92**	**0.042**	**0.056**	**0.009**	**0.096**	**0.055**
Overall Lake Average	**0.125**	**0.045**	**0.893**	**0.094**	**0.063**	**0.012**	**0.065**	**0.089**

Fish Ingestion Rates

The amount of fish eaten by people can be difficult to accurately estimate. It can vary by age, sex, lifestyle, or health status. Fish consumption rates used in this health consultation were provided by the Coeur d’Alene Tribe; IDOH, IDFG, and IDEQ; and by USEPA (Table 3). They cover a wide, but reasonable, range of fish-eating habits that reflect various lifestyles of people who eat fish from Lake Coeur d'Alene. These lifestyles include traditional and contemporary tribal subsistence fish consumers, and sport, recreational or incidental fish consumers. Consideration was also given to fish consumption rates that reflect resident and tourist lifestyles.

To estimate exposures, consistent units are used to describe fish consumption for the purpose of making the calculations. To do this, units of grams per day (g/d) are typically used. Because many people think of their fish consumption in other terms, Table 3 compares fish consumption rates expressed in different ways, including number of fish meals per month. Our calculations were made with (1) portion sizes used by IDOH (adults: 227 grams/meal, 8 oz.; children 114 grams/meal, 4 oz.) and (2) using 30.44 days per month.

The number of fish meals eaten per month can vary widely depending on age, lifestyle and other factors. The information in Table 3 is provided to compare the numbers used solely for calculating exposure doses (grams/day) with other ways, including meals/month, which people may think about fish consumption. Also, IDOH provides guidance in fish consumption advisories based on meals/month. Adults eating 72 eight-ounce fish meals/month or children eating more than 90 four-ounce meals/month is very unlikely, however, these are provided to show how many fish meals/month would be needed to eat 540 grams of fish /day.

Table 3. Fish consumption rates compared in equivalent units and amounts.*

Consumer type	Grams, kilograms and ounces per day	Grams, kilograms and ounces per month	Meals per month	Lbs/year
Recreational Fish Consumer	46g; 0.046kg; 1.6oz	1,400g; 1.4kg; 49oz	6 (adult) 12 (child)	37
Recreational Fish Consumer	65g;0.065kg 2.3oz	1,979g; 1.98kg; 70oz	8-9 (adult) 17 (child)	52.5
Contemporary Subsistence Fish Consumer	170g; 0.170kg; 6oz	5,175g; 5.18kg; 182oz	22-23 (adult) 45 (child)	136.5
Traditional Subsistence Fish Consumer	540g; 0.540kg; 19oz	16,438g; 16.44kg; 579oz	72 (adult) >90 (child)	434

* Note that meals per month are based on an 8 oz (227 g) portion size for adults and a 4 oz (114 g) portion size for children. Using a different portion size would change the number of meals per month.

Of course not every adult may eat an 8 oz portion size, or every child a 4 oz portion size. These are standard portions sizes used for calculation purposes. They are also often used by many states to relay fish consumption advisory information to the general public.

Annual Exposure Factors

An annual exposure factor of one represents someone who consumes a given amount of fish every day of the year. This typically is used to consider worst case exposure scenarios, and is often used to assess exposures to subsistence consumers. Using an annual exposure factor eases the calculation burden, and provides another way to explain exposure duration and frequency. Table 4 shows a range of annual exposure factors that reflect different exposure frequencies and durations. These are provided to help show how frequency and duration of exposure are included in calculations of exposure estimates. It is important to note that only two annual exposure factors were used in this consultation. An annual exposure factor of one (365 days per year) was used for all exposure estimates except those for non-residents. For non-resident exposures, an annual exposure factor of 0.28 (104 days per year) was used.

Table 4. Range of annual exposure factors.

Exposure	Exposure Frequency	Exposure Duration	Number of Days Exposure Occurs	Annual Exposure Factor
Daily	1	12 months	365	**1.0**
	1	9 months	274	0.75
	1	6 months	183	0.50
Five days per week	5/7 (= 0.71)	12 months	259	0.71
	5/7	9 months	194	0.53
	5/7	6 months	130	0.36
Two days per week	2/7 (= 0.28)	12 months	104	**0.28**
	2/7	9 months	79	0.22
	2/7	6 months	53	0.14
One day per week	1/7 (= 0.14)	12 months	52	0.14
	1/7	9 months	39	0.11
	1/7	6 months	26	0.07

Note: 30.44 days per month used for calculations. Only annual exposure factors of 1 and 0.28 were used in this health consultation.

<u>Bioavailability and Absorption Factors</u>

In estimating exposure doses, cadmium, lead, selenium and zinc measured in fish samples were assumed to be completely (100 percent) available. This is reflected in our calculations by using an absorption factor (AF) of 1. Thus, the total values for these four metals were used as they were reported by USEPA (2003). We used this assumption because the actual bioavailability of these metals in fish to humans, while likely to be less than 100%, is difficult to measure and often not known.

For mercury, the total values reported by USEPA (2003) were assumed to be all methyl mercury. Because this form of mercury is highly bioavailable to humans, we assumed that the total mercury values reported by USEPA (2003) were 100% bioavailable. To reflect this in our calculations, we used an absorption factor of 1.

For the total arsenic levels reported by USEPA (2003), we conservatively assumed that 20% was inorganic arsenic, the most toxic form. Fish can absorb inorganic arsenic from water or sediment, and rapidly convert most of it to organic forms. This is a natural process and many fish and shell-fish have high levels of organic arsenic. Organic forms of arsenic are not harmful to people because they are easily and quickly eliminated through the urine. An absorption factor of 0.20 was used to reflect inorganic arsenic levels in our calculations.

<u>Body Weight</u>

We used a body weight of 70 kg (154 lbs.) for adult men and women (including pregnant women) in our calculations (ATSDR 1992). This is a slightly lower body weight than routinely used by the IDOH (80 kg) and makes our exposure estimates a bit more conservative. For children, the body weight used varies from 10 kg (22lbs.) to 35 kg (77lbs) depending on age group. Table 5 shows adult and child body weights used by ATSDR and IDOH. In this consultation, we used a 10 kg body weight for children, (instead of 16 kg or 35 kg), adding to the conservative nature of our evaluation.

Table 5. Body weights for children and adults.

	Body Weights	
Children	ATSDR	Idaho
1 yr old child	10 kg (22 lbs)	----
2-6 yr old children	16 kg (35 lbs)	20 kg (44 lbs)
7-14 yr old	35 kg (77 lbs)	----
Adults	ATSDR	Idaho
General Population	70 kg (154 lbs)	80 kg (176 lbs)
Pregnant Women	70 kg	70 kg

Now that all the individual components of the exposure dose calculation have been presented, the equation shown earlier in this section is given below with abbreviations and units:

$$\underset{(mg/kg/day)}{EED} = \frac{CC\ (mg/kg) \times IR\ (kg/day) \times AEF\ (1\ or\ 0.28) \times AF\ (usually\ 1)}{BW\ (kg)}$$

Ingestion rate is shown here as *kg/day* to eliminate converting between grams (g) and milligrams (mg). Inverting the denominator (1/BW) and multiplying solves the equation. The result is an estimated exposure dose (EED) expressed as *mg* of contaminant per *kg* of body weight per *day*. This is how estimated exposure doses were calculated for this consultation.

Identifying Metals of Concern

Our initial evaluation used conditions that reflect worst case exposures to clearly determine which metals are not of concern and identify metals needing further evaluation. Using this approach, metals that do not present a problem under worst case exposure conditions would not be expected to be of concern under more typical exposure conditions. Our worst case evaluations used the highest concentration for each metal reported by USEPA (2003), the maximum fish consumption rate (540 grams/day) to represent traditional subsistence exposure, an annual exposure factor of 1 (365 days/year) and an absorption factor of 1 (100%). Bioavailability was assumed to be 100%. For adults, a body weight of 70 kg was used and for children a body weight of 10 kg was used. This conservative evaluation resulted in 14 of the 18 metals reported by USEPA (2003) being ruled out from further consideration. Antimony, beryllium and thallium were eliminated from further consideration because they were not detected. Details on the other 11 metals eliminated as contaminants of concern are provided in Appendix C.

Arsenic, cadmium, lead, and mercury were identified as the primary metals of concern. Each of these metals is given further, more detailed, consideration in the following Discussion section. Additional information on arsenic, cadmium, lead, and mercury is provided in Appendix D.

Discussion

Arsenic (As)--Noncancer

Inorganic arsenic is the primary concern in fish and shellfish. Most arsenic in fish and shellfish is in an organic form and is considerably less toxic. The arsenic data provided by USEPA (2003) are total amounts and do not distinguish between inorganic and organic forms. Thus, we do not have a direct measure of the more toxic inorganic form of arsenic. In the human health risk assessment for the Bunker Hill Site, USEPA assumed that 10 % of total arsenic in fish was the inorganic form (TerraGraphics 2000, 2001). IDOH typically also assumes that 10% of total arsenic is inorganic. Studies of arsenic in shellfish indicate that between 3% and 20 % of total arsenic is present in the form of inorganic arsenic (ATSDR 2000). We conservatively assumed that 20% of total arsenic was inorganic (the more toxic form).

The highest average total arsenic value reported by USEPA (2003) was 0.218 mg/kg in bullhead gutted carcass samples from the center sampling area (Table 2). A 70 kg adult consuming 540g of fish daily (traditional subsistence consumer) with an average total arsenic concentration of 0.218 mg/kg (20% of which is inorganic arsenic) would have an estimated exposure dose of 0.00034 mg/kg/day. This is only slightly above the chronic minimal risk level (MRL) of 0.0003 mg/kg/day established by ATSDR (ATSDR 2000). This is the same level as the Reference Dose (RfD) established by USEPA. MRLs and RfDs are daily human exposure estimates considered to have no appreciable risk of adverse non-cancer health effects over a specified length of exposure. Conservative approaches are used in developing MRLs and RfDs. They are often 3-100 times below levels shown to be non-toxic. MRLs are used by ATSDR health assessors to identify contaminants that may be of concern (http://www.atsdr.cdc.gov/mrls.html).

Arsenic concentrations in bass and kokanee gutted carcass samples were on average about 1.5 times below the center lake bullhead gutted carcass sample. Arsenic concentrations in bullhead gutted carcass samples from the north and south lake sampling areas were about 3.5 times less than those from the center lake sampling area. Arsenic concentrations in fillets were typically about one-half of those found in gutted carcass samples (Table 2). This indicates that people consuming fish meals prepared from fillets and gutted carcass portions of a variety of fish species would have exposures lower than our worst case exposure dose. Exposure to arsenic from meals prepared using bullhead gutted carcass portions can be reduced by (1) avoiding bullheads from the center lake sampling area and by (2) using bullhead, bass or kokanee fillets.

Exposure scenarios with a lower consumption rate (170 g/day for contemporary subsistence fish consumer) and less frequent fish consumption (104 days per year for non-residents), result in exposure dose estimates ($\leq$ 0.0001 mg/kg/day) that are well below the MRL or RfD for arsenic. Actual exposures are expected to be less because total intake of fish typically consists of meals prepared with a variety of fish species, not just bullheads. Traditional subsistence consumers eating 540 g or more of fish per day who are concerned about exposure to arsenic could greatly reduce their exposure by switching from gutted carcass portions to fillet portions.

Exposure potential for children was evaluated using the highest average arsenic level (0.218 mg/kg), 20% inorganic arsenic, an ingestion rate of 65 g/day, an AEF of 1 (365 days per year) and a body weight of 10 kg (children 1 YOA). This resulted in an estimated exposure dose of 0.00028 mg/kg/day, which is at about the same level as the chronic oral MRL and the RfD. Other child exposures were estimated using a (1) a body weight of 16 kg (children 2-6 YOA) with an ingestion rate of 65 g/day and (2) a body weight of 35 kg (children 7-14 YOA) with an ingestion rate of 170 g/day. The resulting worst case exposure estimates were 0.00018 mg/kg/day and 0.00021 mg/kg/day, respectively; both of which are below the MRL and the RfD. All other realistic exposure estimates for children were also below the MRL and the RfD.

USEPA (2000) has published adult non-cancer consumption limits for arsenic in fish. These are based on 8 oz. fish portions, a 70 kg body weight, and the RfD (0.0003mg/kg/d). For levels up to 0.088 mg/kg, there is no limit on fish consumption; between 0.088 and 0.180 mg/kg, the limit is 16 eight-oz. fish meals/month; and between 0.180 and 0.230 mg/kg, the consumption limit drops to 12 meals/month. All but one fillet arsenic concentration (Table 2) were in USEPA's unlimited consumption category. Arsenic in the bullhead gutted carcass sample from the center lake area (0.218mg/kg) fell into the 12 meals/month category. Not everyone eats 8 oz. portions, but these USEPA limits provide another way to help us evaluate the Lake Coeur d'Alene fish data reported by USEPA (2003). It also supports the importance of people knowing about their personal fish consumption habits to make better evaluations about health concerns.

Our exposure scenario used to evaluate arsenic assumes that the highest average concentration will be in every fish consumed. While this is not likely to occur, some people may be still be concerned about arsenic accumulation in fish. Fish can absorb inorganic arsenic from water and sediment and rapidly convert most of it to organic arsenic. Common forms of organic arsenic include arsenobetaine, monomethyl arsenic and dimethyl arsenic. This is a natural process and many fish, especially saltwater fish, have high levels of organic arsenic. Organic arsenic is not harmful to people because it is easily and quickly eliminated from the body in urine.

It is important to note the conservative nature of our assumption that 20% of total arsenic is inorganic. The State of Idaho assumes 10% inorganic arsenic for their fish advisory protocol. USEPA (2002c) described the inorganic arsenic content of fish and summarized data that revealed average inorganic arsenic concentrations of 1% and 9% in anadromous and resident species, respectively, collected from the lower Columbia and Willamette rivers. Reducing the amount of inorganic arsenic used in our non-cancer calculations to 10% reduces our worst case exposure estimate by half, which is clearly below the MRL and the RfD.

A person's diet is likely to consist of fillets and gutted carcass portions from a variety of fish species from different parts of the lake. Given all the considerations discussed previously, it is unlikely that non cancer adverse health effects would be expected (for anyone regardless of how much they eat) from exposure to arsenic in bullheads, bass or kokanee from Lake Coeur d'Alene based on the contaminant concentrations reported by USEPA (2003).

Arsenic (As) - Cancer

Using the maximum estimated exposure dose for arsenic calculated previously from gutted carcass data (0.00034 mg/kg/day) and a cancer slope factor of 1.5 (ATSDR 2000), an additional lifetime cancer risk of $5{\times}10^{-4}$ was calculated. This is a 95% upper confidence limit that five additional cancers could occur over a 70 year lifetime if (1) 10,000 people (2) consumed 540 grams of fish every day that (3) contained a total arsenic concentration of 0.218 mg/kg with (4) 20% inorganic arsenic. We are using this as a worst case exposure evaluation.

About one out of every four people (25%) in the U.S develops some type of cancer during their lifetime. Thus, for every 10,000 people about 2,500 would be expected to develop some type of cancer during their lifetime. The maximum arsenic exposure scenario evaluated for consumption of Lake Coeur d'Alene fish in this consultation could increase the number of expected cancer cases from 2,500 to 2,505 over a lifetime. This represents a 95% upper confidence limit that five additional cancer cases could develop if 10,000 people ate 540 grams of fish per day with an arsenic concentration of 0.218 mg/kg over a lifetime. Actual exposures would be expected to be less because people's total intake of dietary fish would consist of a variety of fish species and not just meals prepared with gutted bass carcasses. In addition, the cancer rate is a theoretical estimate of maximum risk and individual risk is likely less, and could be zero.

Two exposure periods shorter than 70 years were considered: 30 years (maximum time at one residence) and 9 years (median time at one residence). These exposure scenarios resulted in excess cancer risks of $2{\times}10^{-4}$ and $7{\times}10^{-5}$ for 30 years and 9 years, respectively, using the maximum exposure dose previously calculated (0.00034 mg/kg/day).

Maximum exposure conditions for contemporary subsistence fish consumers (170 g/day) and recreational fish consumers (65g/day) resulted in excess cancer risk estimates of $2x10^{-4}$ and $6{\times}10^{-5}$, respectively. For a non-resident recreational fish consumer (65g/day, 104 days per year), an excess cancer risk of $2{\times}10^{-5}$ was calculated. This represents a 95% upper confidence limit that two additional cancers could be expected over a lifetime if 100,000 people consumed fish with an As level of 0.218 mg/kg (with 20% inorganic arsenic) at a rate of 65 g/day for 104 days/year. This risk would increase the number of expected cancer cases from 25,000 to 25,002.

The highest arsenic value in fillet samples (0.116 mg/kg) was about one-half of the highest gutted carcass mean. This translates to lower estimated exposure doses of 0.00018, 0.00006, and 0.00002 mg/kg/day for traditional subsistence (540 g/day), contemporary subsistence (170 g/day) and resident recreational fish consumers (65 g/day), respectively. The additional cancer risks associated with these exposure scenarios were $3{\times}10^{-4}$, $8{\times}10^{-5}$, and $3{\times}10^{-5}$, respectively. For non-resident recreational/sport fish consumers (65 g/day, 104 days/yr), a maximum exposure dose of 0.000006 mg/kg/day was estimated for arsenic in fillets. The associated increased cancer risk for this exposure scenario is $9{\times}10^{-6}$. Upper limit cancer risk estimates for exposures to arsenic in Lake Coeur d'Alene fish are compared in Table 6. The highest mean arsenic level for each species (Table 2) was used.

Cancer risks from potential exposure to carcinogens are estimated by using mathematical models to estimate maximum likely additional cancer risks. Estimated additional cancer risks for specific exposures may often be stated as 1×10^{-6}, or one in one million. This means that in a population of one million people exposed to a carcinogen over a lifetime, one additional case of cancer (beyond the 25,000 that would be expected) may occur. This represents a 95% upper confidence limit estimate of additional cancer risk. The true risk is not known, but will likely be lower.

It is important to note again that additional cancer risk means above and beyond what is considered background or normal. Based on health statistics for the United States, one out of four people (25 %) develop some type of cancer in their lifetime, which is generally assumed to be 70 years. This is typically considered as the background cancer rate in the United States. Thus, for every one million people living in the United States, about 250,000 would be expected to develop some type of cancer over their lifetime. If we calculate an excess risk of one in a million (1×10^{-6}) for a specific chemical exposure, and one million people are exposed over an entire lifetime, then one additional cancer case would be expected (or 250,001 cases). If 10,000 people are exposed at a 1×10^{-6} risk level, it is not very likely than an increase of cancer in the population could be measured. If several million people were exposed, then one might be able to measure an increase in cancer. Calculations of excess cancer risk apply only to populations, not to individuals. The excess cancer risk estimates do not predict the actual risk of any individual person developing cancer.

Table 6. Upper limit excess cancer risk estimates for arsenic in Lake Coeur d'Alene fish.

		Gutted Carcass	Fillet	Risk Category Summary
Fish Consumer	Exposure Period	Bullheads		Gutted Carcass/Fillet
Traditional Subsistence	70 yrs	5×10^{-4}	3×10^{-4}	Increased
Traditional Subsistence	30 yrs	2×10^{-4}	1×10^{-4}	Increased
Traditional Subsistence	9 yrs	7×10^{-5}	3×10^{-5}	Moderate
Contemporary Subsistence	70 yrs	2×10^{-4}	8×10^{-5}	Increased
Contemporary Subsistence	30 yrs	7×10^{-5}	4×10^{-5}	Moderate
Contemporary Subsistence	9 yrs	2×10^{-5}	1×10^{-5}	Moderate
Recreational, Resident	70 yrs	6×10^{-5}	3×10^{-5}	Moderate
Recreational, Non-resident	70 yrs	2×10^{-5}	9×10^{-6}	Moderate
		Bass		
Traditional Subsistence	70 yrs	3×10^{-4}	1×10^{-4}	Increased
Traditional Subsistence	30 yrs	1×10^{-4}	6×10^{-5}	Increased
Traditional Subsistence	9 yrs	4×10^{-5}	2×10^{-5}	Moderate
Contemporary Subsistence	70 yrs	1×10^{-4}	5×10^{-5}	Increased/Moderate
Contemporary Subsistence	30 yrs	5×10^{-5}	2×10^{-5}	Moderate
Contemporary Subsistence	9 yrs	1×10^{-5}	6×10^{-6}	Moderate
Recreational, Resident	70 yrs	4×10^{-5}	2×10^{-5}	Moderate
Recreational, Non-resident	70 yrs	1×10^{-5}	5×10^{-6}	Moderate/Low
		Kokanee		
Traditional Subsistence	70 yrs	3×10^{-4}	2×10^{-4}	Increased
Traditional Subsistence	30 yrs	1×10^{-4}	8×10^{-5}	Increased
Traditional Subsistence	9 yrs	4×10^{-5}	2×10^{-5}	Moderate
Contemporary Subsistence	70 yrs	1×10^{-4}	6×10^{-5}	Increased
Contemporary Subsistence	30 yrs	5×10^{-5}	3×10^{-5}	Moderate
Contemporary Subsistence	9 yrs	1×10^{-5}	8×10^{-6}	Moderate
Recreational, Resident	70 yrs	1×10^{-5}	2×10^{-5}	Moderate
Recreational, Non-resident	70 yrs	1×10^{-5}	6×10^{-6}	Moderate/Low

In this consultation, ATSDR staff determined that the maximum estimated exposure dose for arsenic could result in an excess cancer risk is 5×10^{-4}, or 5 in 10,000. This says that if 10,000 people eat 540 grams of fish with 0.218 mg/kg arsenic every day for seventy years, the expected number of cancer cased could increase by five and go from 2,500 to 2,505.

Conservative estimates for additional cancer risks for arsenic were in the 10^{-5} to 10^{-6} range for (1) resident and non-resident recreational/sport fish consumers; (2) contemporary subsistence consumers of fillets; and (3) for some less than lifetime exposures for traditional subsistence consumers (Table 6). Lifetime (70 yrs) exposure estimates for traditional subsistence fish consumers were in the 10^{-4} range. Switching to fillets could appreciably reduce risks (from 10^{-4} to 10^{-5} or from 10^{-5} to 10^{-6}) in some cases, as could lower overall consumption rates.

Cadmium (Cd)

The maximum average cadmium concentration reported by USEPA (2003) was 0.139 mg/kg found in the kokanee gutted carcass sample (Appendix B). Using this along with our highest ingestion rate (540 g/day for traditional subsistence consumer), an annual exposure factor of 1 (person exposed 365 days per year) and an absorption factor of 1 (all the cadmium measured in fish is bioavailable to human consumer), yields a worst case estimated exposure dose of 0.0011 mg/kg/day. This is about five times higher than the chronic oral MRL for cadmium (0.0002 mg/kg/day). USEPA has established an oral RfD of 0.001 mg/kg/day for cadmium. Actual exposures are expected to be less because people likely consume fish meals prepared from fillets and gutted carcass portions of a variety of fish species. Also, people eating lower amounts of fish or consuming fish less frequently would have lower exposures.

In bass and bullhead gutted carcass samples, average cadmium values were 2-17 times lower than in the kokanee gutted carcass sample. Average cadmium concentrations in fillet samples from all three species were from 8-28 times lower than in the kokanee gutted carcass sample (Table 2). This indicates that people eating meals prepared from fillets and gutted carcass portions of these fish species would have exposures much lower than our worst case estimated dose. Exposure to cadmium from consuming kokanee gutted carcass portions can be reduced by eating (1) kokanee fillets and (2) bass or bullhead gutted carcasses or fillets.

For non-resident adult recreational consumers (65 g/day, 104 days/yr) and contemporary subsistence consumers (170 g/day, 365 days/yr), estimated exposures to cadmium were 0.000036 and 0.00034 mg/kg/day, respectively. Resident adult recreational fish consumers were estimated to have a maximum exposure dose of 0.00013 mg/kg/day. These exposures are below, or well within the same concentration range as, the MRL. None of these exposure estimates exceed the RfD. Overall, if people consume a variety of fish species from Lake CDA, cadmium exposures are expected to be about 2-28 times lower than our worst case estimate.

The maximum exposure dose for children 7-14 years old was estimated using the highest average cadmium concentration (0.139 mg/kg), an ingestion rate of 65 g/day, an annual exposure factor of 1 (exposed 365 days per year), an absorption factor of 1 (100% absorbed), and a body weight of 35 kg. Using these components, a maximum exposure dose of 0.00026 mg/kg/day was calculated. This does not exceed the RfD, and is in the same range as the MRL. Actual exposures would be expected to be less if a variety of fish species are eaten. We do not think that young children are likely to consume more than 65 grams of fish per day on an annual basis.

Conservative aspects of our exposure estimates include using the highest average level reported by USEPA (2003). People's diets are likely to consist of fillets and gutted carcass portions of several fish species from different parts of the lake. Based on cadmium concentrations provided by USEPA (2003), lake averages for bullhead and bass gutted carcass samples were about 3-9 times lower, respectively, than in the kokanee gutted carcass specimens. Lake averages for bass and bullhead fillets were about 9 to 15 times, respectively, lower than the kokanee gutted carcass value used in our exposure dose estimate. The overall average for cadmium in fillet samples was about 3 times lower than in gutted carcass samples (Table 2).

USEPA (2000) has published consumption limits for cadmium in fish. These are based on 8 oz. fish portions, a 70 kg body weight, and the RfD (0.001 mg/kg/d). For cadmium levels up to 0.088 mg/kg, there is no limit on consumption. Between 0.088 and 0.180 mg/kg, the limit on consumption is 16 eight-ounce fish meals per month. At cadmium levels between 0.180 and 0.230 mg/kg, the consumption limit drops to 12 meals per month. While not everyone may eat 8 oz. portions, the USEPA limits provide another way to help evaluate the fish data reported in the Coeur d'Alene Fish Investigation (USEPA 2003). This also helps to show how important information on personal fish consumption habits is when making evaluations on health impacts. Given our assumptions, adverse health effects associated with realistic adult or child exposures to cadmium in bullheads, bass or kokanee from Lake Coeur d'Alene are not considered likely.

While cadmium can be carcinogenic when inhaled, human or animal studies have not provided sufficient evidence to show that cadmium is a carcinogen by oral routes of exposure (ATSDR 1999b). Thus, cancer evaluations for cadmium were not done as part of this consultation.

<u>Lead (Pb)</u>

Average lead concentrations reported for gutted carcass samples in the Coeur d'Alene Lake Fish Investigation were highest (3.85 mg/kg) in bullheads from the center lake sampling area. Average lead levels were 113 times lower (0.034 mg/kg) in bass from the southern sampling area (Table 2). Lake averages for bass (0.129 mg/kg) and kokanee (0.115 mg/kg) gutted carcass samples were 15-16 times below the average for bullhead gutted carcass samples (1.92 mg/kg).

Mean lead levels in fillet samples varied from 0.232 mg/kg in bullheads from the center lake sampling area to 0.020 mg/kg in bass and kokanee (Table 2). For the three species collected, average lead levels in fillets were 6-20 times lower as compared to gutted carcass samples of the same species. The overall average lead concentration in fillets (0.065 mg/kg) was about 14 times lower than the overall average calculated for gutted carcass samples (0.893 mg/kg). Lead is known to accumulate in bones, likely accounting for higher levels in gutted carcass samples.

Maximum estimated exposure doses calculated ranged from 0.001 mg/kg/day for a recreational, non-resident fish consumer (65 g/day, 104 days/year) to 0.030 mg/kg/day for a traditional subsistence fish consumer (540 g/day; 365 days/year). There is currently no MRL or RfD available for lead to allow direct comparison to these estimated exposure doses. Lead exposures are evaluated further in the following sections with regard to increases in blood lead levels.

Increases in Blood Lead (Pb) Concentrations

The approach described by ATSDR (1999b, Appendix D) was used to estimate blood lead increases that could result from exposures to lead in Lake Coeur d'Alene fish. Daily lead intakes from fish, a component of exposure dose calculations, were converted to micrograms (µg) and used to estimate lead (µg Pb) ingested per day. Estimated lead intakes were multiplied by diet slope factors, which have units of <u>µg of Pb/dL of blood</u> **per** <u>ug Pb ingested/day</u>, resulting in estimated blood lead increases in units of µg/dL. Diet slope factors of 0.034 and 0.027 µg/dL per µg Pb ingested/day were used for adult females and males, respectively. A diet slope factor of 0.24 µg/dL per µg Pb ingested/day was used for children. Using average lead levels in fish (Table 2), estimated blood lead increases were calculated for subsistence and recreational consumption scenarios for both sample types and all three species (Table 7).

Adult traditional (540 g/day) and contemporary (170 g/day) subsistence consumers of bullhead gutted carcass portions could exceed the 10µg/dL blood lead level used as a benchmark by the Centers for Disease Control and Prevention (CDC). Adult resident sport/recreational fish consumers with elevated blood lead levels could exceed 10 µg/dL if they eat 65 g/day or more of bullhead gutted carcass portions (Table 7). Adult non-resident consumers (65 g/day; 104 days/yr) would not be expected to have elevated blood lead levels from eating the fish species and portion types which we evaluated. Adult resident consumers would not be expected to have elevated blood lead levels from eating bass or kokanee gutted carcass or fillet portions, or bullhead fillets.

CDC (2003) reported blood lead levels for four age groups (Table 7). Children who eat 65 g/day or more of bullhead gutted carcass portions could reach or exceed the 10 µg/dL CDC benchmark (Table 8). Children 1-5 YOA with blood lead levels at the 95th percentile level reported by CDC (2003) could exceed the CDC benchmark if they eat as little as 6.5 g/day of bullhead gutted carcass portions (Tables 8, 9). Children could eat more bass or kokanee gutted carcass portions, or bullhead fillets before reaching a 10 µg/dL blood lead level. Eating fish fillets results in lower lead exposures for all fish consumers (Table 8).

Table 7. Blood lead levels (µg/dL) reported by CDC (2003).

Age Groups (years of age, YOA)	Geometric Mean	95th Percentile
1-5	2.23 (1.99-2.49)	7.00 (5.20-9.90)
6-11	1.51 (1.35-1.69)	4.50 (3.30-6.30)
12-19	1.10 (1.03-1.18)	2.80 (2.50-3.00)
20 +	1.75 (1.67-1.83)	5.20 (4.70-5.70)

* 95% confidence intervals shown in parentheses.

Assumptions for the estimated blood lead increases shown in Table 8 are very conservative. People likely eat a variety of fish species, portion types, and amounts (Table 3) from different locations. Daily exposures to high lead levels are not expected. Our approach helps us to evaluate worst case exposures, target concerns, and to guide people in determining where their individual exposures may fall. Additional discussion of lead exposures in children is provided in the later section on Children's Health Considerations.

Table 8. Estimated blood lead increases (µg/dL) for adults and children.

Fish Species	Sample Type	Average Lead Value (mg/kg)	Fish Ingestion Rate (g/day)	Annual Exposure Factor	Lead Ingested Per Day (µg)	Blood Lead Increases Adults (F)	Adults (M)	Children
Bullhead	Gutted Carcass	1.92	540	1	1036.8	35.251	27.994	
		1.92	170	1	326.4	11.098	8.813	78.336
		1.92	65	1	124.8	4.243	3.370	29.952
		1.92	65	0.28	34.944	1.188	0.943	8.378
		1.92	6.5	1	12.48	0.424	0.337	2.995
Bass	"	0.129	540	1	69.66	2.368	1.881	
		0.129	170	1	21.93	0.746	0.592	5.263
		0.129	65	1	8.385	0.285	0.226	2.012
		0.129	65	0.28	2.3478	0.080	0.063	0.563
		0.129	6.5	1	0.8385	0.028	0.023	0.201
Kokanee	"	0.115	540	1	62.1	2.111	1.677	
		0.115	170	1	19.55	0.665	0.528	4.692
		0.115	65	1	7.475	0.254	0.202	1.794
		0.115	65	0.28	2.093	0.071	0.057	0.502
		0.115	6.5	1	0.7475	0.025	0.020	0.179
Bullhead	Fillet	0.096	540	1	51.84	1.763	1.400	
		0.096	170	1	16.32	0.555	0.441	3.917
		0.096	65	1	6.24	0.212	0.168	1.498
		0.096	65	0.28	1.7472	0.059	0.047	0.419
		0.096	6.5	1	0.624	0.021	0.017	0.150
Kokanee	"	0.020	540	1	10.8	0.367	0.292	
		0.020	170	1	3.4	0.116	0.092	0.816
and		0.020	65	1	1.3	0.044	0.035	0.312
		0.020	65	0.28	0.364	0.012	0.010	0.087
Bass		0.020	6.5	1	0.13	0.0044	0.0035	0.031

Note: Traditional and contemporary subsistence, and resident recreational fish consumers are represented by fish ingestion rates of 540, 170 and 65 g/day, respectively, and an annual exposure of 1 (365 days/yr). Non-resident recreational fish consumers are indicated by the annual exposure factor of 0.28 (104 days/yr). Average lead (Pb) concentrations are lake averages from Table 2. F indicates females and M indicates males.

Mercury (Hg)

The highest mean mercury level reported by USEPA (2003) was 0.188 mg/kg in bass fillets from the center of Lake CDA. Mercury levels in bass fillet and gutted carcass samples were 2-4 times greater than those in bullhead or kokanee, likely because bass are top predators. The mercury levels reported by USEPA (2003) were assumed to be methyl mercury, the more toxic form.

Adult non-resident recreational fish consumer (65 g/day,104 days/yr) exposure estimates were below the ATSDR MRL (0.0003 mg/kg/day) and the EPA RfD (0.0001 mg/kg/day). For adult resident recreational fish consumers (65 g/day, 365 days/year), exposure estimates were less than the MRL and the RfD for all samples except bass fillets (Table 9). Adult contemporary subsistence consumer exposure estimates were above the MRL for bass, above the RfD for kokanee, and below the RfD for bullheads. For traditional subsistence adults, exposure estimates exceeded the MRL for all three species. Both the MRL and the RfD are for methyl mercury.

Using a fish ingestion rate of 6.5 g/day resulted in child exposure doses below the RfD for children 2-6 YOA and 7-14 YOA (Table 9). For children 1 YOA, the 6.5 g/day rate resulted in doses below the RfD in all cases except bass fillets. A fish ingestion rate of 65 g/day yielded exposure estimates above the RfD in all cases, and many times above the MRL, for 1 year old children and 2-6 year old children. It is not considered very likely that 1 year old children will consume 65 g of fish each day. For the 7-14 year old group, using 65 g/day indicated exposures below the RfD in bullheads and in kokanee gutted carcass portions; other exposures fell between the RfD and the MRL. Children 7-14 YOA eating fish at 170g/day could exceed the MRL for bass and kokanee, and the RfD for bullheads. Avoiding bass fillets would reduce exposures.

ATSDR’s MRL is based on the Seychelles Child Development Study of over 700 mother-infant pairs in the Seychelles Islands. This population eats a large quantity and variety of fish, with 12 fish meals/week being typical. This is likely as much, or more, than people using Lake CDA for their source of dietary fish. Mercury levels in 350 fish (25 species) ranged from 0.5-0.75 ppm, which is higher than in the Lake CDA fish sampled. Developing fetuses were exposed *in utero* through maternal fish ingestion during pregnancy. Newborn children continued to be exposed during breast feeding and after their shift to a fish diet (ATSDR 1999a). In the 66-month evaluation period of the Seychelles study, multiple developmental domains were assessed with six tests. None of these indicated adverse effects of methyl mercury exposure. The study also mentioned positive benefits of the fish diet. ATSDR derived a no observed adverse effect level (NOAEL) of 0.0013 mg/kg/day from the highest exposure group in this study. The MRL was derived by applying an uncertainty factor of 3 for human variability and a modifying factor of 1.5 to account for domain specific findings in the Faroe Islands study (ATSDR 1999a).

IDOH uses the RfD for methyl mercury for fish consumption advisories. The RfD is based on a benchmark dose analysis of developmental and neurological impairment. The RfD and the MRL differ by a factor of three, but they are in the same concentration range. Although derived by different methods, the RfD and the MRL are both relevant to Lake Coeur d’Alene, especially given concerns about preventing adverse fetal and infant exposures to methyl mercury.

Table 9. Estimated exposure doses for mercury.

Fish Species	Sample Type	Mercury Level (mg/kg)	Ingestion Rate (g/day)	Annual Exposure Factor	Adult Exposure Dose	Above RfD/MRL	Child (7-14 YOA) Exposure Dose	Above RfD/MRL	Child (2-6 YOA) Exposure Dose	Above RfD/MRL	Child (1 YOA) Exposure Dose	Above RfD/MRL
Bass	Fillet	0.188	540	1	0.001450	**Yes**						
		0.188	170	1	0.000457	**Yes**	0.000913	**Yes**				
		0.188	65	1	0.000175	*Yes/No*	0.000349	*Yes/No*	0.000764	**Yes**	0.001222	**Yes**
		0.188	65	0.28	0.000049	No	0.000098	No	0.000214	*Yes/No*	0.000342	**Yes**
		0.188	6.5	1	0.000017	No	0.000035	No	0.000076	No	0.000122	*Yes/No*
		0.188	6.5	0.28	0.000005	No	0.000010	No	0.000021	No	0.000034	No
Bass	Gutted Carcass	0.152	540	1	0.001173	**Yes**						
		0.152	170	1	0.000369	**Yes**	0.000738	**Yes**				
		0.152	65	1	0.000141	*Yes/No*	0.000282	*Yes/No*	0.000618	**Yes**	0.000988	**Yes**
		0.152	65	0.28	0.000040	No	0.000079	No	0.000173	*Yes/No*	0.000277	*Yes/No*
		0.152	6.5	1	0.000014	No	0.000028	No	0.000062	No	0.000099	No
		0.152	6.5	0.28	0.000004	No	0.000008	No	0.000017	No	0.000028	No
Kokanee	Fillet	0.092	540	1	0.000710	**Yes**						
		0.092	170	1	0.000223	*Yes/No*	0.000447	**Yes**				
		0.092	65	1	0.000085	No	0.000171	*Yes/No*	0.000374	**Yes**	0.000598	**Yes**
		0.092	65	0.28	0.000024	No	0.000048	No	0.000105	No	0.000167	*Yes/No*
		0.092	6.5	1	0.000009	No	0.000017	No	0.000037	No	0.000060	No
		0.092	6.5	0.28	0.000002	No	0.000005	No	0.000010	No	0.000017	No
Kokanee	Gutted Carcass	0.075	540	1	0.000579	**Yes**						
		0.075	170	1	0.000182	*Yes/No*	0.000364	**Yes**				
		0.075	65	1	0.000070	No	0.000139	*Yes/No*	0.000305	*Yes/No*	0.000488	**Yes**
		0.075	65	0.28	0.000020	No	0.000039	No	0.000085	No	0.000137	*Yes/No*
		0.075	6.5	1	0.000007	No	0.000014	No	0.000030	No	0.000049	No
		0.075	6.5	0.28	0.000002	No	0.000004	No	0.000009	No	0.000014	No

Table 9, continued. Estimated exposure doses for mercury.

Fish Species	Sample Type	Mercury Level (mg/kg)	Ingestion Rate (g/day)	Annual Exposure Factor	Adult Exposure Dose	Above RfD/MRL	Child (7-14 YOA) Exposure Dose	Above RfD/MRL	Child (2-6 YOA) Exposure Dose	Above RfD/MRL	Child (1 YOA) Exposure Dose	Above RfD/MRL
Bullhead	Fillet	0.055	540	1	0.000424	**Yes**						
		0.055	170	1	0.000134	*Yes/No*	0.000267	*Yes/No*				
		0.055	65	1	0.000051	No	0.000102	No	0.000223	*Yes/No*	0.000358	**Yes**
		0.055	65	0.28	0.000014	No	0.000029	No	0.000063	No	0.000100	No
		0.055	6.5	1	0.000005	No	0.000010	No	0.000022	No	0.000036	No
		0.055	6.5	0.28	0.000001	No	0.000003	No	0.000006	No	0.000010	No
Bullhead	Gutted Carcass	0.042	540	1	0.000324	**Yes**						
		0.042	170	1	0.000102	No	0.000204	*Yes/No*				
		0.042	65	1	0.000039	No	0.000078	No	0.000171	*Yes/No*	0.000273	*Yes/No*
		0.042	65	0.28	0.000011	No	0.000022	No	0.000048	No	0.000076	No
		0.042	6.5	1	0.000004	No	0.000008	No	0.000017	No	0.000027	No
		0.042	6.5	0.28	0.000001	No	0.000005	No	0.000005	No	0.00008	No

Note: A single yes indicates that the respective estimated exposure dose was above the MRL and the RfD. A single no indicates that the respective estimated exposure dose was below the RfD and the MRL. Yes/no indicates exposure doses falling above the RfD and below the MRL. A 35 kg body weight was used for children 7- 14 years of age (YOA), 16 kg for children 2-6 YOA, and 10 kg for 1 year old children.

Our conservative exposure scenarios indicate that adverse health effects could result from fetal or infant exposures to mercury in fish from Lake Coeur d'Alene, especially bass fillets. Mercury levels in bullhead and kokanee were 2-4 times below that in bass. Pregnant women, women of child-bearing age, and young children could reduce mercury exposures by not eating bass.

<u>Arsenic, Cadmium, Lead and Mercury Concentrations in Lake Coeur d'Alene Fish</u>

Overall average cadmium, lead and mercury concentrations were higher in the Lake Coeur d'Alene samples collected in 2002 (Tables 2, 11) than in samples from the lateral lakes (Table 11) previously evaluated by ATSDR (1998). The different species, sample types and specimen sizes collected in these studies allow only general comparisons.

Data reported from other investigations of contaminant residues in fish can help provide some perspective on the occurrence of metals in fish in Lake Coeur d'Alene. Comparison of data reported by USEPA (2003) with results reported by other investigators must be done cautiously. Different species, sample types, and specimen sizes are important factors to consider when comparing different studies on metals in fish.

Schmitt and Brumbaugh (1990) evaluated seven metals in whole-body fish samples from a variety of species collected nationwide from 1976-1984. These data provide a robust comparison base for arsenic, cadmium, mercury and lead levels for the gutted carcass samples (Tables 2, 11) reported by USEPA (2003). Metal levels in gutted carcass samples should usually be lower than in whole-body samples. A basic comparison (Table 12) indicates this is the case for the Coeur d'Alene samples, except for mercury in bass, cadmium in kokanee, and lead in bullheads.

More recently USGS (2002) reported that arsenic was found in 28% of fish samples from the Mississippi River Basin, cadmium in 49%, lead in 87%, and mercury in 97% (Table 13). Highest levels of As (0.3-0.56 µg/g) were almost always found in largemouth bass. Arsenic tends to accumulate more in planktivorous fish species, which are often prey for bass (USGS 2002).

Average arsenic, cadmium and mercury levels in bass and bullhead gutted carcass samples from Lake Coeur d'Alene (USEPA 2003) were below, or about the same as, the whole-body samples from the USGS (2002) reference site. Average lead in bass and bullhead gutted carcass samples from Lake Coeur d'Alene were usually higher than the reference site and the maximum sub-basin or station mean reported by USGS (2002). Average lead levels in bullhead gutted carcass samples from the north and center Lake Coeur d'Alene sampling areas were higher than the maximum whole body lead value (Table 13) reported by USGS (2002).

Eight fish-related food items (Table 14) in the Food and Drug Administrative (FDA) Total Diet Studies Database were compared to fish samples from Lake Coeur d'Alene. Preferences for these foods in the Lake Coeur d'Alene area are unknown. Mean arsenic levels in the Lake Coeur d'Alene samples were lower than the FDA food items while average cadmium levels were about the same. Lead and mercury concentrations in the 2002 Lake Coeur d'Alene fish samples, and in the lateral lakes samples evaluated by ATSDR (1998), were higher than in fish-related FDA Total Diet food items (Table 14). Over 250 food items are contained in the FDA Total Diet Studies database (Pennington 1992).

Table 10. Overall lake averages (mg/kg, wet weight) for arsenic, cadmium, lead and mercury reported by USEPA (2003).

Species and Sample Type	Arsenic (As)	Cadmium (Cd)	Lead (Pb)	Mercury (Hg)
Bass, gutted carcass	0.129	0.015	0.129	0.152
Bass, fillet	0.064	0.015	0.020	0.188
Kokanee, gutted carcass	0.145	0.139	0.115	0.075
Kokanee, fillet	0.083	0.018	0.020	0.092
Bullhead, gutted carcass	0.113	0.044	1.92	0.042
Bullhead, fillet	0.056	0.009	0.096	0.055
Overall Average	0.098	0.040	0.383	0.101

Table 11. Summary of results (mg/kg) from health consultation on lateral lakes (ATSDR 1998).

Metal	Overall Average		Maximum Average	Lake	Species
Cadmium	0.015		0.042	Medicine Lake	Yellow perch
Lead	0.209		0.115	Medicine Lake	Yellow perch
Mercury	0.08		0.495	Killarney Lake	Northern pike

Table 12. Comparison of As, Cd, Pb, and Hg in samples collected nation-wide with Lake Coeur d' Alene fish samples.

Schmitt et al 1990		2002 Lake Coeur d'Alene Samples		
Metal	Range of Means 1976-1984	Bass	Kokanee	Bullhead
Arsenic (As)	0.14-0.27	Below/within range	Below/within range	Below/within range
Cadmium (Cd)	0.03-0.07	Below/within range	Above range	Below/within range
Lead (Pb)	0.11-0.28	Below/within range	Below/within range	Above range
Mercury (Hg)	0.10-0.12	Above range	Below/within range	Below/within range

Note: 1976-1984 data is for whole-body fish samples; concentrations reported as µg/g, wet weight (equivalent to mg/kg); means reported as geometric.

Table 13. Metal concentrations in bass and carp samples from the Mississippi River Basin (USGS 2002).

USGS Status and Trends Data	Arsenic (As)	Cadmium (Cd)	Lead (Pb)	Mercury (Hg)
Frequency of Detection in Fish Samples	28%	49%	87%	97 %
Frequency of Detection at Sampling Sites	48%	91%	100%	100 %
Maximum Metal Concentration	0.56	0.51	0.69	0.45
Sub-basin Average Concentration Range, Bass	0.07-0.24*	0.018-0.162*	0.01-0.04	0.14-0.33
Reference Site Concentration, Bass	<0.12	<0.02-0.03	0.01	0.22
Sub-basin Average Concentration Range, Carp	0.07-0.24*	0.018-0.162*	0.06-0.14	0.09-0.17
Reference Site Concentration, Carp	<0.12	<0.02-0.03	0.11	0.04

Notes: Samples were whole-body fish. Concentrations reported as µg/g, wet weight (equivalent to mg/kg concentrations used elsewhere in this consultation). Asterisk (*) denotes that the ranges shown for As and Cd are approximate station averages across species, not sub-basin averages.

Table 14. Average As, Cd, Pb and Hg concentrations (mg/kg, wet weight) for eight fish-related items in the FDA market basket database.

FDA Market Basket Food Item	FDA Food Item No.	Arsenic (As)	Cadmium (Cd)	Lead (Pb)	Mercury (Hg)
Tuna, canned in oil	32	0.88	0.020	0.001	0.165
Fish sticks, frozen	34	0.92	0.010	0.001	0.005
Haddock, pan cooked	243	5.5	0.002	0.003	0.070
Shrimp, boiled	244	0.80	0.015	0.032	0.027
Tuna noodle casserole	272	0.107	0.016	0.003	0.023
Fish sandwich, fast food	276	0.54	0.012	0.005	0.002
New England clam chowder, canned	285	0.137	0.014	0.008	ND*
Salmon steaks/filets (fresh or frozen), baked	318	0.38	0.002 (max)	ND*	0.029
Overall Average	---	1.158	0.011	0.007	0.029

Note: ND = not detected. Average metal concentrations obtained from Total Diet Study Statistics on Element Results, U.S. Food and Drug Administration (2001), Washington, DC. Available from the internet site: http://www.cfsan.fda.gov/~acrobat/TDS1byel.pdf. Some additional information on total diet studies is provided by Pennington (1992).

Children's Health Considerations

Lead

Children are more sensitive to elevated blood lead levels because their brain, nervous system and other organ systems are still developing. Incomplete development of the blood-brain barrier in fetuses and young children (up to 3 years of age) increases the risk of lead entering the nervous system. This can result in prolonged or permanent neurobehavioral disorders. Renal, endocrine, and hematic systems may also be adversely affected. As more sensitive studies and measures are developed, threshold exposure levels for many of these effects are being revised downward.

Blood lead readily crosses the placenta, putting the developing fetus at risk. This is especially important in the neurological development of the fetus because there is no blood-brain barrier. The mother's blood lead level is an important indication of risk to the fetus. In addition, mothers who had previous elevated exposure to lead may store it in their bones, from which it could be released during times of calcium stress, such as pregnancy and lactation.

ATSDR recognizes that children can be more sensitive to chemical exposures than adults. The ATSDR public health assessment for the Coeur d'Alene site includes children's exposures to metals in soil, dust and other media, and the potential health effects of these exposures.

Children exposed to lead residentially and from recreational activities may have an increased risk of developing neurological problems. These children may have elevated blood lead levels and be especially susceptible to additional exposures to lead from eating locally caught fish. This is especially true for gutted carcass fish portions because lead tends to accumulate more in the non-fillet portions of fish than in the fillet. Consuming contaminated fish in great quantity, coupled with residential and possibly recreational exposures, could result in various adverse health effects. Pregnant and nursing women should also limit the amount of locally caught fish that they consume in order to decrease the chance of contaminants being transferred to the fetus/infant.

Inside the Box

The population living in the 21 square mile Bunker Hill Superfund Site (often referred to as “the Box”) has been the focus of several lead health studies since 1974. Soil and house dust with high lead levels have been identified as primary causes of elevated blood lead levels for these people. Typical lead concentrations in wastes and soils within the Bunker Hill smelter complex reach or exceed 10% (100,000 ppm). In the early 1980s, soils in residential yards “in the Box” averaged 2,500-5,000 ppm while house dust lead levels averaged 2,000-4,000 ppm. The 1983 Lead Health Study revealed that about 80% of a child’s lead intake was from incidental ingestion of soil and dust. About 40% of this intake appeared to come from indoor house dusts, 30% from home yard soils, and 30% from neighborhood or community-wide sources.

Since 1974, over 6,000 blood lead screens have been performed for children living in the Bunker Hill site. Up to 75% of preschool children tested during the 1970s had elevated blood lead levels. During that time, mean blood lead levels for preschool children living within one mile of the Bunker Hill Complex were almost 70 µg/dL. Since 1974, the Panhandle Health District (PHD) has implemented effective public health education interventions to combat elevated blood lead levels in these children. The PHD has received help from IDOH, Bureau of Environmental Health and Safety (BEHS, now the Bureau of Community and Environmental Health), CDC and ATSDR. A steady decline in blood lead levels has been observed in children living “in the Box.” In 1988, 46% of children screened “in the Box” had a blood lead level ≥10 µg/dL compared to 3% in 2001. Children participating in these screenings were 6 months to 9 years old. During the summer of 2002, 259 children through 6 years of age were tested. Of these, only six children (2%) had blood lead levels ≥10 µg/dL. The mean blood lead level was 2.8 µg/dL.

Outside the Box

In 1996, BEHS and PHD conducted the Coeur d’Alene River Basin Environmental Health Exposure Assessment in communities located “outside the Box.” The assessment showed that exposure pathways identified for residents living “in the Box” also exist for individuals living “outside the Box.” Tailings in the river’s floodplain in this area average 2% lead. In soil near the river, lead typically ranges from 2,000-12,000 ppm in the Lower Basin (western half of the site “outside the Box”) and from 500-25,000 ppm in the Upper Basin (eastern half of the site “outside the Box”). Lead in soil samples typically averages 2,500 – 2,800 ppm in this area.

In the early 1970s, children tested who lived “outside the Box” often had blood lead levels of 40-50 µg/dL. No regular child blood lead screening occurred in this area from 1975-1996. In 1996, blood lead screening was offered to children 6 months - 9 years old as part of the Coeur d’Alene River Basin Environmental Health Exposure Assessment. Of the children tested in 1996, 13.7% had elevated blood lead (≥10 µg/dL). Since 1996, screenings “outside the Box” have been done annually. In 2000, 8.93% of the children (6 months - 9 years old) screened had elevated blood lead levels. The mean blood level for the 117 children (6 months - 6 years) screened in 2001 was 3.7 µg/dL, and 6% had elevated blood levels. Children 7-9 years old “outside the Box” were not screened in 2001 due to funding decreases. For the 103 children screened in 2002, the mean blood lead value was 3.2 µg/dL, and four (4%) had elevated blood lead levels.

Mean blood levels for children living inside and outside the Box are similar to mean levels reported by CDC (2003). Children with mean blood lead levels could eat 65 g/day of fish fillets (bullhead, kokanee or bass) or gutted carcass portions (kokanee or bass) and be expected to have blood lead levels of 5 µg/dL or less. Children who eat 65 g/day of bullhead gutted carcass portions would likely exceed the 10 µg/L benchmark. Children 1-5 YOA with blood lead levels similar to the 95th percentile value reported by CDC (2003) could exceed 10 µg/dL by eating as little as 6.5 g/day of gutted bullhead carcass portions (Tables 8, 9).

Mercury

Infants and children can be much more sensitive to methyl mercury induced neurotoxicity than adults. Critical periods of neonatal development and the early months after birth are times that are particularly sensitive to the harmful effects of methyl mercury on the nervous system. Exposure to methyl mercury is more dangerous for young children than for adults because methyl mercury more easily passes into the developing brain of young children and may interfere with developmental processes. Methyl mercury can accumulate in fetal blood to concentrations higher than in the mother. Abnormal heart rhythms have been seen in children who ate grains contaminated with very high levels of methyl mercury. Methyl mercury that enters the body can be converted to inorganic mercury and result in kidney damage.

Additional information on arsenic, cadmium, lead and mercury is provided in Appendix D.

Benefits of Fish Consumption

It is important to consider the benefits of eating fish as part of a balanced diet of traditional and contemporary foods. Fish are an excellent protein source and are associated with reduced risk of coronary heart disease. The benefits of eating fish have been associated with low levels of unsaturated fats (e.g., omega-3 polyunsaturated fatty acids) which are essential nutrients. Saturated fats are linked with increased cholesterol levels and risks of heart disease. Fish also provide a good source of some vitamins and minerals. The American Heart Association recommends two servings of fish per week as part of a healthy diet.

The health benefits of eating fish deserve particular consideration when dealing with subsistence consumer populations. Removing fish from these diets can have serious health, social and economic consequences. Providing accurate, balanced information is very important to help people make informed decisions about the risks and benefits of personal fish consumption. Benefits of traditional foods in healthy diets are receiving more attention as tribes focus more attention on contaminant impacts to their trust resources (ADPH 1998).

Fish can be a source of essential trace elements required by the body in small amounts to function normally. Several of the metals determined not to be contaminants of concern in Lake Coeur d'Alene fish are essential trace elements. Table 15 shows tolerable upper intake levels for seven such metals found in Lake Coeur d'Alene fish. Maximum estimated adult daily intakes were generally within the levels established. Average exposure conditions by age group would also likely be well within these limits. This helps to illustrate the balance needed in weighing the risks versus benefits when making decisions about fish consumption.

Table 15. Tolerable upper intake levels (ULs) by life stage group.

Life Stage Group	Copper (μg/d)	Manganese (mg/d)	Molybdenum (μg/d)	Nickel (mg/d)	Selenium (μg/d)	Vanadium (mg/d)	Zinc (mg/d)
0-6 months	ND	ND	ND	ND	45	ND	4
7-12 months	ND	ND	ND	ND	60	ND	5
1-3 yrs	1,000	2	300	0.2	90	ND	7
4-8 yrs	3,000	3	600	0.3	150	ND	12
9-13 yrs	5,000	6	1,100	0.6	280	ND	23
14-18 yrs	8,000	9	1,700	1	400	ND	34
19-50 yrs	10,000	11	2,000	1	400	1.8	40
> 50 yrs	10,000	11	2,000	1	400	1.8	40
Pregnant: ≤18 yrs	8,000	9	1,700	1	400	ND	34
Pregnant: 19-50 yrs	10,000	11	2,000	1	400	ND	40
Lactation: ≤18 yrs	8,000	9	1,700	1	400	ND	34
Lactation: 19-50 yrs	10,000	11	2,000	1	400	ND	40
Lactation: 19-50 yrs	10,000	11	2,000	1	400	ND	40
Max. Daily Intake from Lake Coeur d'Alene Fish	1,080 µg/d	9.7	82	1.88	404	0.111	19.4

Table Notes:
These tolerable upper intake levels (ULs) are part of the new Dietary Reference Intake (DRI) values that are replacing the old Recommended Daily Allowance (RDA) values.

Tolerable Upper Intake Level (UL) is defined as the highest level of daily nutrient intake that is likely to pose no risks of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the risk of adverse effects increases. Unless specified otherwise, the UL represents total nutrient intake from food, water, and supplements.

Information extracted from three books by the Food and Nutrition Board of the Institute of Medicine (view or order books from www.nap.edu):
Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. (2001, 650 p).

Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. (1999, 448 p).

Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids. (2000, 529 p).

Vanadium in food has not been shown to cause adverse effects in humans. The UL is based on adverse effects in laboratory animals. These data were used to set UL for adults, but not children or adolescents. There is no known reason to add vanadium to food. Vanadium supplements should be used with caution.

ND = Not determinable due to lack of data on adverse effects in this age group and concern about lack of ability to handle excess amounts. Source should be food only to prevent high levels of intake.

Maximum daily intakes calculated in manner similar to estimated exposure doses in Appendix C (used the maximum metal concentration × maximum ingestion rate).

Conclusions

1. In Lake Coeur d'Alene fish samples collected in 2002, 14 metals were eliminated as contaminants of concern (antimony, barium, beryllium, chromium, cobalt, copper, manganese, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc. Worst case exposure conditions were used and included maximum metal levels, a traditional subsistence fish consumption rate (540 g/day), and other factors (Appendix C). Although people are exposed to these metals in fish, adverse health effects are not likely to occur. *No apparent public health hazard* exists for children or adults exposed to these metals in bass, kokanee or bullheads from Lake Coeur d'Alene.

2. Conservative evaluation for non-cancer effects of arsenic (i) used the highest average level (0.218 mg/kg, bullhead gutted carcass), (ii) assumed 20% inorganic arsenic, and (iii) used traditional subsistence consumption rates. Although people are exposed to arsenic in fish, the resulting exposure dose estimates for adults and children are below levels that have been associated with health effects. For non-cancer effects of arsenic, *no apparent public health hazard exists* for adults or children exposed to arsenic levels found in bass, kokanee or bullheads from Lake Coeur d'Alene.

3. Conservative assessments for carcinogenic effects of arsenic exposures were done using (i) resident and non-resident exposure durations, (ii) the highest average arsenic levels for gutted carcass and fillet samples, and (iii) assuming that inorganic arsenic was 20% of total arsenic. Non-resident recreational consumer scenarios had the lowest excess cancer risk estimates while traditional subsistence consumer scenarios for gutted carcass portions had the highest (Table 6). *No apparent public health hazard* is considered to exist for non-resident recreational consumers exposed to arsenic in fillets of bullheads, bass or kokanee. A *public health hazard* may exist for traditional subsistence consumers exposed to arsenic in gutted carcass portions of bullheads, bass or kokanee because of increased consumption rates and higher arsenic concentrations in these samples.

4. Conservative evaluation of cadmium used the maximum average concentration (0.139 mg/kg, kokanee gutted carcass) and traditional subsistence consumption rates. Although some exposure dose calculations indicate the possibility of elevated exposures to cadmium, people typically consume a variety of fish species, use both fillet portions and gutted carcass portions, and eat lower amounts of fish than we used in our calculations. Each of these factors would result in exposures below our estimates. Therefore, *no apparent public health hazard* is considered to exist for children or adults exposed to cadmium in bullheads, bass or kokanee from Lake Coeur d'Alene.

5. Conservative evaluations of lead exposures were done using resident and non-resident exposure conditions. Average lead levels were used and the bioavailability of lead was assumed to be 100%. Estimated increases in blood lead were highest for traditional subsistence consumers of bullhead gutted carcass portions and lowest for non-resident, recreational consumers (Table 8). A *public health hazard* may exist for adult traditional and contemporary subsistence consumers of bullhead gutted carcass portions, especially from the center sampling area of the lake. A *public health hazard* may also exist for adult, resident

recreational consumers with existing blood lead levels > 6-7µg/dL who eat gutted bullhead portions, especially from the center sampling area of the lake. *No apparent public health hazard* is considered to exist for adult, non-resident recreational consumers exposed to lead in the species and portion types which we evaluated. *No apparent public health hazard* is likely to exist for adults eating fillets of bullhead, bass or kokanee, or for adults eating gutted bass or kokanee portions.

6. Conservative evaluation of child lead exposures indicated that bullhead gutted carcass portions could push blood lead levels beyond the CDC benchmark (10µg/dL). Children (1-5 and 6-11 YOA) who are at the 95th percentile level reported by CDC (2003), bass and kokanee gutted carcass portions, and bullhead fillets, could have elevated blood lead levels if they consume 170 g/day (contemporary subsistence) or more. A *public health hazard* may exist for children who consume bullhead gutted carcass portions. A *public health hazard* may also exist for children (1-5 and 6-11 YOA) with elevated blood lead levels if they eat 170 g/day or more of gutted bass or kokanee portions or bullhead fillets. Children with major exposures to lead in soil or household dust are most likely to have elevated lead levels.

7. Conservative evaluation of mercury used the maximum average concentration (0.188 mg/kg in bass fillets from the center sampling area). This was 2-4 times higher than mercury levels found in bullheads or kokanee. Exposure dose estimates for traditional and contemporary subsistence fish consumers indicated the possibility of elevated exposures and adverse effects. Thus, a *public health hazard* may exist for pregnant women, women of childbearing age, young children, and adults who are subsistence fish consumers. *No apparent public health hazard* is thought to exist for non-resident recreational fish consumers exposed to the mercury levels found in these Lake Coeur d'Alene fish. *No apparent public health hazard* is likely for children eating 6.5 g of fish per day or less. *A public health hazard* could exist for children (2-6 and 7-14 YOA) who eat more than 65 g day of fish per day.

8. Overall average cadmium, lead and mercury concentrations were higher in the Lake Coeur d'Alene fish samples collected in 2002 than in the fish samples from the lateral lakes which were previously evaluated by ATSDR (1998). Different species and specimen sizes were collected these two studies.

9. Average arsenic, cadmium, and mercury levels in the 2002 bass and bullhead gutted carcass samples from Lake Coeur d'Alene were below, or comparable to, whole-body samples from the USGS (2002) reference site. Average lead concentrations in bass and bullhead gutted carcass samples from Lake Coeur d'Alene were usually higher than the reference site and the highest sub-basin or station means reported by USGS (2002). In bullhead gutted carcass samples from the north and center Lake Coeur d'Alene sampling areas, average lead levels were higher than the maximum whole body lead value (Table 13) reported by USGS (2002).

10. Average arsenic concentrations were lower in the Lake Coeur d'Alene samples than in eight fish-related food items found in the FDA Total Diet Studies Database (Table 14). Average cadmium levels in the Lake Coeur d'Alene fish samples were similar to levels found in eight fish-related food items found in the FDA Total Diet Studies Database. Lead and mercury concentrations in the 2002 Lake Coeur d'Alene fish samples, and in the lateral lakes samples

evaluated by ATSDR (1998), were higher than in the eight fish-related food items found in the FDA Total Diet Studies database (Table 14).

11. Several essential trace elements (copper, manganese, molybdenum, nickel, selenium, zinc) found in Lake Coeur d'Alene fish were determined not to be contaminants of concern. They were also considered to be within the respective tolerable upper intake limits that have been established (Table 15), especially for average exposure conditions. When making decisions about fish consumption, consideration should be given to balancing the risks versus benefits.

12. We used conservative approaches to evaluate adverse health impacts from exposure to 18 metals found in two portion types of three fish species Lake Coeur d'Alene. We first determined that 14 metals were not likely to be of concern. Four metals (arsenic, cadmium, lead and mercury) were then evaluated further using maximum and average metal levels, subsistence and recreational fish consumption rates, and other factors (Appendix C). As a result, cadmium was determined to present *no apparent public health hazard*. The remaining three metals (arsenic, lead and mercury) were determined to present varying degrees of concern depending on the amount, portion type (gutted carcass or fillet), and fish species eaten (Table 16).

13. Eating fish offers both benefits and risks. We recognize that fish consumption rates are an important factor in assessing exposures and the potential for adverse effects. A wide range of consumption rates (6.5 to 540 g/day) and several exposure scenarios are included in this consultation. These were used to help gain a better idea of which fish consumption habits are more likely to result in adverse exposures.

Table 16. Summary of hazard category conclusions.

	Subsistence				Recreational			
	Traditional		Contemporary		Resident		Non-resident	
	Adult	Child	Adult	Child	Adult	Child	Adult	Child
Bullheads, Gutted								
As-Noncancer	No	No	No	No	No	No	No	No
As-Cancer	Yes	---	Yes	---	Yes	---	Yes	---
Cd	No	No	No	No	No	No	No	No
Pb	Yes	Yes	Yes	Yes	Yes*	Yes	No	Yes
Hg	Yes	Yes	Yes[a]	Yes	No	Yes	No	No
Bullheads, Fillet								
As-Noncancer	No	No	No	No	No	No	No	No
As-Cancer	Yes	---	Yes	---	Yes	---	No	---
Cd	No	No	No	No	No	No	No	No
Pb	No	Yes	No	Yes*	No	No	No	No
Hg	Yes	Yes	Yes[a]	Yes	No	Yes	No	No
Bass, Gutted								
As-Noncancer	No	No	No	No	No	No	No	No
As-Cancer	Yes	---	Yes	---	Yes	---	Yes	---
Cd	No	No	No	No	No	No	No	No
Pb	No	Yes	No	Yes*	No	Yes*	No	No
Hg	Yes	Yes	Yes	Yes	Yes[a]	Yes	No	No
Bass, Fillets								
As-Noncancer	No	No	No	No	No	No	No	No
As-Cancer	Yes	---	Yes	---	Yes	---	No	---
Cd	No	No	No	No	No	No	No	No
Pb	No	No	No	No	No	No	No	No
Hg	Yes	Yes	Yes	Yes	Yes[a]	Yes	No	No
Kokanee Gutted								
As-Noncancer	No	No	No	No	No	No	No	No
As-Cancer	Yes	---	Yes	---	Yes	---	Yes	---
Cd	No	No	No	No	No	No	No	No
Pb	No	Yes	No	Yes*	No	No	No	No
Hg	Yes	Yes	Yes[a]	Yes	No	Yes	No	No
Kokanee Fillets								
As-Noncancer	No	No	No	No	No	No	No	No
As-Cancer	Yes	---	Yes	---	Yes	---	No	---
Cd	No	No	No	No	No	No	No	No
Pb	No	Yes	No	No	No	No	No	No
Hg	Yes	Yes	Yes[a]	Yes	No	Yes	No	No

Note: For non-cancer categories, "Yes" denotes a conclusion of public health hazard; "Yes[a]" specifies pregnant women and women of child-bearing age; "No" denotes no apparent public health hazard.

For cancer, only lifetime exposures (70 yrs) are shown. No indicates low cancer risk (10^{-6} risk level); Yes indicates moderate (10^{-5} risk level) or increased (10^{-4} risk level) cancer risk. "Yes*" indicates public health hazard for people with elevated blood lead levels.

Recommendations/Public Health Advice/Public Health Action Plan

ATSDR and the IDOH will provide the findings of this health consultation to the public and to the Coeur d'Alene Tribe. The following information will be included*:*

- Overall exposure to metals in fish from Lake Coeur d'Alene can be reduced by eating fillet portions instead of gutted carcass portions.

- Children (infants to 11 years old) should limit their consumption of meals prepared from bullhead, bass, and kokanee from Lake Coeur d'Alene.

- Adults, particularly pregnant women, should limit the number of meals prepared from bass, bullhead gutted carcass portions, and kokanee from Lake Coeur d'Alene.

IDOH will provide fish consumption advisory information to the public.

In June 2003, the Idaho Division of Health released a fish consumption advisory based on the results reported by USEPA (2003) and the suggested meal limits shown in Appendix E. A large outreach effort has been initiated with the Division of Health and the Coeur d'Alene Tribe. Commonly used access areas are to be posted with the advisory. The advisory (Appendix F) can be accessed at Idaho agency internet sites such as http://www2.state.id.us/dhw/behs/index.htm (click on Fish Advisories). Access to this site was verified on 21 August 2003. ATSDR provided a letter of support regarding the issuance of the fish consumption advisory in June 2003. This consult was prepared to complete our joint assessment of the fish data used for the advisory.

Update http://www.accessidaho.org/ **links to reflect the 2003 advisory information**

Fish consumption advisory information can be accessed at http://www.accessidaho.org/, clicking on agency index, and selecting "Health and Welfare, Department of" (verified on 21 August 2003). The http://www.accessidaho.org/ site can also be searched for "fish consumption advisories".

Fish advisory information should be provided through the Coeur d'Alene Tribe's web site http://www.cdatribe.org/

No fish advisory-related information could be found on the Coeur d'Alene Tribe's web site as of 21 August 2003**.** This should be added to the site as part of tribal education and outreach efforts.

Any future sampling and analysis of fish should include inorganic arsenic analysis.

The fish advisory issued by IDOH lists future actions that include sampling fish in future years, and analyzing the samples collected in 2002 for polychlorinated biphenyls (PCBs).

Authors of Report

William A. Robison, Ph.D.
Toxicologist
Agency for Toxic Substances and Disease Registry (ATSDR)
Division of Health Assessment and Consultation

Lijun Jin, Toxicologist
Idaho Division of Health
Bureau of Community and Environmental Health

Reviewers of Report

Déborah A. Boling, M.P.H.
Health Assessor
ATSDR, Division of Health Assessment and Consultation
Superfund Site Assessment Branch

Richard Kauffman, M.S.
Senior Regional Representative, Region 10
ATSDR, Office of Regional Operations

Sven Rodenbeck, Sc.D., P.E., D.E.E.
Section Chief
ATSDR, Division of Health Assessment and Consultation
Superfund Site Assessment Branch

Marc Stifelman, Environmental Toxicologist
USEPA, Region 10
Office of Environmental Assessment, Risk Evaluation Unit

Ann E. Bradley
University of Washington, MPH Candidate
ATSDR Region 10

Elke Shaw-Tulloch, M.H.S, Chief
Bureau of Community and Environmental Health
Idaho Division of Health
Idaho Department of Health and Welfare

Aaron Scheff, M.Ed.
Bureau of Community and Environmental Health
Idaho Division of Health
Idaho Department of Health and Welfare

References

ADPH. 1998. The Use of Traditional Foods in a Healthy Diet in Alaska: Risks in Perspective. January 15, 1998. Alaska Division of Public Health. Anchorage, AK.

AHA. 2000. An Eating Plan for Healthy Americans. American Heart Association internet site: http://www.americanheart.org/dietaryguidelines /images/EatPlan2000.pdf.

ATSDR 1989. The Relationship of Human Lead and Cadmium Levels with Consumption of Fish Caught in and Around Lake Coeur d'Alene. Final Report: Technical Assistance to the Idaho State Health Department and the Indian Health Service. Agency for Toxic Substances and Disease Registry. June, 1989.

ATSDR 1992. Public Health Assessment Guidance Manual. Agency for Toxic Substances and Disease Registry, Atlanta, GA. March 1992.

ATSDR 1995. A Case-Control Study to Determine Risk Factors for Elevated Blood Lead Levels in Children, the Silver Valley, Idaho. Agency for Toxic Substances and Disease Registry, Atlanta, GA. August 1995.

ATSDR 1997a. Study of Female Former Workers at a Lead Smelter: an examination of the possible association of lead exposure with decreased bone density and other health outcomes. Agency for Toxic Substances and Disease Registry, Atlanta, GA. July 1997.

ATSDR 1997b. A Cohort Study of Current and previous residents of the Silver Valley: assessment of lead exposure and health outcomes. Agency for Toxic Substances and Disease Registry, Atlanta, GA. August 1997.

ATSDR 1998. Health Consultation: Coeur d'Alene Lateral Chain Lakes, Kootenai County, Idaho. Agency for Toxic Substances and Disease Registry, Atlanta, GA. July 22, 1998.

ATSDR 1999a. Toxicological Profile for Mercury (Update). Agency for Toxic Substances and Disease Registry, Atlanta, GA. March 1999.

ATSDR 1999b. Toxicological Profile for Cadmium. Agency for Toxic Substances and Disease Registry, Atlanta, GA. July 1999.

ATSDR. 1999c. Toxicological Profile for Lead. Agency for Toxic Substances and Disease Registry, Atlanta, GA. July 1999.

ATSDR. 2000a. Public Health Consultation: Coeur d'Alene River Basin Panhandle Region of Idaho, including Benewah, Kootenai, & Shoshone Counties. Basin-Wide Residential Properties Sampled under Field Sampling Plan Addendum 06 (FSPA06). Agency for Toxic Substances and Disease Registry, Atlanta, GA. May 2000.

ATSDR. 2000b. Toxicological Profile for Arsenic. Agency for Toxic Substances and Disease Registry, Atlanta, GA. September 2000.

Bennett, D, M Falter and W Sawle. 1990. Pilot Sampling for Heavy Metals in Fish Flesh from Killarney Lake, Coeur d'Alene River System, Idaho. Prepared for Bureau of Land Management. Technical Bulletin 90-6. September, 1990.

CDC. 2003. Second National Report on Human Exposure to Environmental Chemicals. National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, GA. January. 2003.

CH2M HILL and URS Greiner. 2001. *Final Ecological Risk Assessment for the Coeur d'Alene RI/FS.* Prepared for USEPA, Region 10. May 2001.

Coeur d'Alene Tribe. 2001. *Preliminary Study Plan Proposal: Coeur d'Alene Lake Fish Sampling for Trace Metals.* October 2001.

FDA. 2001. Total Diet Study Statistics on Element Results. U.S. Food and Drug Administration (2001), Washington, DC. (http://www.cfsan.fda.gov/~acrobat/TDS1byel.pdf.).

IDOH, 2003. Health Consultation: Selenium in Fish in Streams of the Upper Blackfoot River Watershed. Idaho Department of Health, Boise, Idaho.

Lanphear, BP, K Dietrich, P Auinger, and C Cox. 2000. Cognitive Deficits Associated with Blood Lead Concentrations <10 µg/dL in US Children and Adolescents. Public Health Reports 115(6):521-529.

Pennington, JAT. 1992. Total diet studies: the identification of core foods in the United States food supply. Food Additives and Contaminants 9(3):253-264.

Schmitt, CJ and WG Brumbaugh. 1990. National Contaminant Biomonitoring Program: Concentrations of Arsenic, Cadmium, Copper, Lead, Mercury, Selenium, and Zinc in U.S. Freshwater Fish, 1976-1984. Arch. Environ. Contam. Toxicol 19:731-747.

Steele, MJ, BD Beck, BL Murphy, HS Strauss.1990. Assessing the Contribution from Lead in Mining Wastes to Blood Lead. Regulatory Toxicology and Pharmacology. 11:158-190.

TerraGraphics, 2000a. Human Health Risk Assessment for the Coeur d'Alene Basin Extending form Harrison to Mullan on the Coeur d'Alene River and Tributaries: Remedial Investigation/Feasibility Study. Public Review Draft. TerraGraphics Environmental Engineering, Inc.; URS Greiner, in association with CH2M HILL. July 2000.

TerraGraphics. 2001. Final Human Health Risk Assessment for the Coeur d'Alene Basin Extending From Harrison to Mullan on the Coeur d'Alene River and Tributaries. Prepared for USEPA, Region 10. June 2001.

URS Greiner and CH2M Hill. 2001a. Final Remedial Investigation Report, Coeur d'Alene Basin. Prepared for USEPA, Region 10. October 2001.

URS Greiner and CH2M Hill. 2001b. Final Feasibility Study Report, Coeur d'Alene Basin. Prepared for USEPA, Region 10. October 2001.

USEPA. 1994. Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. EPA/540/R-94/013. US Environmental Protection Agency, Washington, DC. Feb. 1994.

USEPA. 1997. Exposure Factors Handbook, Volume 1 - General Factors. US Environmental Protection Agency, Washington, DC. August 1997.

USEPA. 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Vol. 2: Risk Assessment and Fish Consumption Limits. US Environmental Protection Agency, Washington, DC. November 2000.

USEPA. 2001. Proposed Plan, Coeur d'Alene Basin. US Environmental Protection Agency, Washington, DC. October 2001.

USEPA. 2002a. *Fish Investigation Plan, Coeur d'Alene Basin.* U.S. Environmental Protection Agency, Region 10. Prepared by URS Greiner, Seattle, WA. April 2002.

USEPA. 2002b. *Record of Decision, Coeur d'Alene Basin.* Prepared by URS Greiner, Seattle, WA. September 2002.

USEPA. 2002c. *Columbia River Basin Fish Contaminant Survey, 1996-1998.* U.S. Environmental Protection Agency, Region 10. Seattle, WA. July 2002.

USEPA. 2003. Coeur d'Alene Lake Investigation Data Report, Coeur d'Alene, Idaho. May 2003. US Environmental Protection Agency. Prepared by URS Greiner, Inc., Seattle, WA.

USEPA and TERA. 1999. Comparative Dietary Risks: Balancing the Risks and Benefits of Fish Consumption. US Environmental Protection Agency (USEPA) and Toxicology Excellence for Risk Assessment (TERA). August 1999.

USGS. 2002. Biomonitoring of Environmental Status and Trends (BEST) Program: Environmental Contaminants and their Effects on Fish in the Mississippi River Basin. CJ Schmitt, editor. Biological Science Report USGS/BRD/BSR-2002-004. US Dept. of the Interior, US Geological Survey.

Appendix A
Analytical Results for As, Cd, Pb, Hg, in Fish Samples
Collected from Lake Coeur d'Alene in 2002 (USEPA 2003)

Table A-1. Coeur d'Alene Lake Analytical Results for Bass Samples

Sample Type	Collection Location	Sample Number	Percent Lipid (%)	Q	Moisture (%)	Arsenic (mg/kg) wet	Q	Cadmium (mg/kg) wet	Q	Lead (mg/kg) wet	Q	Mercury (mg/kg) wet
GC	Center	02194049	0.50%	U	76.4	0.080		0.012	U	0.035		0.158
GC	Center	02194050	0.40%	U	74.7	0.134		0.013	U	0.268		0.229
GC	Center	02194060 *	0.50%	U	77.15	0.123		0.006	U	0.104		0.187
GC	Center	02194061	1.00%		75.3	0.146		0.012	U	0.111		0.108
GC	Center	02194062	0.50%	U	74.9	0.108		0.012	U	0.306		0.119
GC	Center	02194063	0.90%		74.9	0.211		0.017		0.276		0.131
GC	Center	02194082	1.00%		75.2	0.062	U	0.014		0.114		0.341
GC	Center	02194083	0.60%	U	75.7	0.080		0.012	U	0.234		0.180
GC	Center	02194084	0.50%	U	74.5	0.130		0.013	U	0.334		0.132
GC	Center	02194085	0.50%	U	77.6	0.105		0.011	U	0.183		0.126
Geometric Mean						0.112		0.012		0.165		0.161
Average						0.118		0.012		0.197		0.171
Maximum						0.211		0.017		0.334		0.341
Minimum						0.062		0.006		0.035		0.108
GC	North	02194000 *	0.90%		72.95	0.034	U	0.007	U	0.045		0.122
GC	North	02194001	0.50%	U	76.3	0.078		0.019		0.221		0.094
GC	North	02194024	0.70%	U	76.7	0.093		0.015		0.042		0.129
GC	North	02194025	0.70%	U	77	0.209		0.044		0.055		0.357
GC	North	02194026	0.50%	U	78.1	0.215		0.020		0.135		0.118
GC	North	02194027	0.60%	U	75.7	0.148		0.029		0.467		0.325
GC	North	02194028	0.70%	U	75.8	0.085		0.022		0.159		0.105
GC	North	02194029 *	0.70%	U	74.4	0.083		0.006	U	0.010		0.075
GC	North	02194030	0.60%	U	76.2	0.155		0.023		0.324		0.233
GC	North	02194031	0.60%	U	77.1	0.179		0.030		0.105		0.179
Geometric Mean						0.112		0.018		0.098		0.152
Average						0.128		0.022		0.156		0.174
Maximum						0.215		0.044		0.467		0.357
Minimum						0.034		0.006		0.010		0.075
GC	South	02194004	0.70%	U	76.2	0.102		0.012	U	0.012	U	0.100
GC	South	02194034	1.00%		76.2	0.162		0.012	U	0.012	U	0.108
GC	South	02194035	NA		75.6	0.095		0.013		0.046		0.170
GC	South	02194036	0.40%	U	75.6	0.129		0.012	U	0.054		0.114
GC	South	02194065	0.80%		76.5	0.235		0.017		0.047		0.112
GC	South	02194068 *	0.50%	U	73.8	0.113		0.067		0.011		0.121
GC	South	02194069	0.40%	U	74.8	0.164		0.012	U	0.012	U	0.099

Table A-1. Coeur d'Alene Lake Analytical Results for Bass Samples

Sample Type	Collection Location	Sample Number	Percent Lipid (%)	Q	Moisture (%)	Arsenic (mg/kg) wet	Q	Cadmium (mg/kg) wet	Q	Lead (mg/kg) wet	Q	Mercury (mg/kg) wet
GC	South	02194072	0.80%		74	0.073		0.012	U	0.012	U	0.136
GC	South	02194073	0.80%		74.6	0.218		0.013	U	0.013	U	0.064
GC	South	02194074	0.60%	U	74	0.164		0.018		0.153		0.092
Geometric Mean						0.137		0.016		0.024		0.108
Average						0.146		0.019		0.037		0.111
Maximum						0.235		0.067		0.153		0.170
Minimum						0.073		0.012		0.011		0.064
FL	Center	02194064 *	0.50%	U	79.15	0.115		0.005		0.017		0.194
FL	Center	02194079	0.50%	U	80.8	0.108		0.108		0.027		0.176
FL	Center	02194080	0.40%	U	80.1	0.050	U	0.010	U	0.019		0.153
FL	Center	02194081	0.50%	U	80.8	0.048	U	0.009	U	0.009	U	0.144
FL	Center	02194086	0.40%	U	79.8	0.057		0.010	U	0.019		0.149
FL	Center	02194087	0.50%	U	79.6	0.059		0.010	U	0.012		0.386
FL	Center	02194088	0.40%	U	80.1	0.056		0.010	U	0.024		0.275
FL	Center	02194089	0.40%	U	80.2	0.069		0.010	U	0.010	U	0.139
FL	Center	02194090	0.40%	U	79.5	0.100		0.010	U	0.023		0.121
FL	Center	02194091	0.40%	U	79.7	0.051	U	0.011	U	0.047		0.139
Geometric Mean						0.068		0.012		0.018		0.176
Average						0.071		0.019		0.021		0.188
Maximum						0.115		0.108		0.047		0.386
Minimum						0.048		0.005		0.009		0.121

Notes:

FL - fillet; GC - gutted carcass

mg/kg - milligram per kilogram

% - percent

Q - validation qualifier

U - not detected

* - field duplicate pair, average concentrations

Table A-2. Coeur d'Alene Lake Analytical Results for Bullhead Samples

Sample Type	Collection Location	Sample Number	Percent Lipid (%)	Q	Moisture (%)	Arsenic (mg/kg) wet	Q	Cadmium (mg/kg) wet	Q	Lead (mg/kg) wet	Mercury (mg/kg) wet
GC	Center	02194033 *	0.50%	U	76.2	0.046		0.009		0.146	0.037
GC	Center	02194051*	0.50%	U	79	0.510		0.115		4.757	0.057
GC	Center	02194052	0.50%	U	78.5	0.280		0.088		5.375	0.075
GC	Center	02194053	0.60%	U	77.4	0.249		0.070		4.271	0.049
GC	Center	02194054	0.50%	U	79.8	0.511		0.164		14.120	0.053
GC	Center	02194055	2.10%		79.3	0.068		0.112		2.546	0.039
GC	Center	02194056	0.40%	U	79.1	0.052	U	0.036		0.451	0.025
GC	Center	02194057	0.50%	U	77.4	0.063		0.027		0.070	0.032
GC	Center	02194058	0.50%	U	77.6	0.056	U	0.060		0.349	0.041
GC	Center	02194059	0.40%	U	80	0.400		0.090		6.400	0.043
Geometric Mean						0.145		0.060		1.448	0.043
Average						0.224		0.077		3.849	0.045
Maximum						0.511		0.164		14.120	0.075
Minimum						0.046		0.009		0.070	0.025
GC	North	02194005	1.10%	J	76.5	0.089		0.035		1.260	0.043
GC	North	02194006	0.70%	U	77.5	0.056	U	0.038		1.150	0.021
GC	North	02194011	0.50%	U	78.3	0.095		0.028		1.031	0.024
GC	North	02194012	0.70%	U	78.2	0.072		0.028		0.822	0.017
GC	North	02194013	0.60%	U	77.8	0.058		0.027		2.309	0.029
GC	North	02194014	0.70%	U	77.9	0.077		0.049		0.782	0.023
GC	North	02194015	0.60%	U	77.6	0.063		0.027		0.544	0.028
GC	North	02194016	0.80%	U	77.5	0.086		0.034		2.102	0.027
GC	North	02194020 *	0.70%	U	77.95	0.048		0.020		0.517	0.020
GC	North	02194021	0.80%		77.6	0.099		0.056		3.696	0.051
Geometric Mean						0.072		0.033		1.171	0.027
Average						0.074		0.034		1.421	0.028
Maximum						0.099		0.056		3.696	0.051
Minimum						0.048		0.020		0.517	0.017
GC	South	02194070 *	0.80%		75.85	0.051		0.018		0.226	0.046
GC	South	02194071 *	0.50%	U	78	0.068		0.013		0.103	0.049
GC	South	02194092	0.50%	U	77	0.058		0.011	U	0.347	0.056
GC	South	02194093	0.50%	U	76.7	0.058	U	0.017		1.240	0.071
GC	South	02194094	0.50%	U	78.8	0.110		0.051		1.353	0.053
GC	South	02194095	0.50%	U	79.7	0.051	U	0.010	U	0.190	0.040
GC	South	02194096	0.50%	U	77.6	0.056	U	0.056		0.576	0.055
GC	South	02194097	0.50%	U	76.3	0.059	U	0.012	U	0.047	0.048

Table A-3. Coeur d'Alene Lake Analytical Results for Kokanee Samples

Sample Type	Collection Location	Sample Number	Percent Lipid (%)	Q	Moisture (%)	Arsenic (mg/kg) wet	Q	Cadmium (mg/kg) wet	Q	Lead (mg/kg) wet	Q	Mercury (mg/kg) wet
FL	Center	02334005	1.10%		73.1	0.110		0.019		0.046		0.083
FL	Center	02334006	0.90%		73.4	0.090		0.019		0.014		0.079
FL	Center	02334007	0.60%	U	74.6	0.117		0.012	U	0.024		0.101
FL	Center	02334009	0.70%	U	74.8	0.088		0.016		0.016		0.096
FL	Center	02334010	1.60%		72.9	0.084		0.014	U	0.014	U	0.096
FL	Center	02334014 *	0.80%		74.25	0.051		0.021		0.011		0.094
FL	Center	02334015	0.70%	U	73.8	0.079		0.024		0.018		0.104
FL	North	02334016	1.40%		74.3	0.064		0.019		0.013		0.081
FL	North	02334017	1.50%		73.4	0.072		0.029		0.035		0.094
FL	North	02334018	0.70%	U	73.9	0.076		0.017		0.019		0.089
Geometric Mean						0.081		0.018		0.019		0.091
Average						0.083		0.019		0.021		0.092
Maximum						0.117		0.029		0.046		0.104
Minimum						0.051		0.012		0.011		0.079
GC	South	02334000	5.30%		70.7	0.179		0.120		0.179		0.072
GC	South	02334001	3.00%		68.9	0.156		0.164		0.146		0.074
GC	North	02334002 *	2.60%		69.55	0.140		0.122		0.076		0.073
GC	North	02334003	5.30%		69.8	0.142		0.205		0.091		0.085
GC	North	02334004	1.60%		69.6	0.140		0.112		0.073		0.078
GC	North	02334008	3.00%		67.7	0.194		0.142		0.120		0.085
GC	North	02334011	2.60%		69.7	0.133		0.170		0.061		0.078
GC	North	02334012	3.80%		70.8	0.169		0.137		0.128		0.071
GC	North	02334013	3.40%		71.1	0.116		0.118		0.104		0.067
GC	Center	02334019	3.10%		69.9	0.123		0.123		0.200		0.071
GC	Center	02334020	2.40%		75.1	0.105		0.112		0.087		0.073
Geometric Mean						0.143		0.136		0.108		0.075
Average						0.145		0.139		0.115		0.075
Maximum						0.194		0.205		0.200		0.085
Minimum						0.105		0.112		0.061		0.067

Notes:
FL - fillet; GC - gutted carcass
mg/kg - milligram per kilogram
% - percent
Q - validation qualifier
U - not detected
* - field duplicate pair, average concentrations

Table A-2. Coeur d'Alene Lake Analytical Results for Bullhead Samples

Sample Type	Collection Location	Sample Number	Percent Lipid (%)	Q	Moisture (%)	Arsenic (mg/kg) wet	Q	Cadmium (mg/kg) wet	Q	Lead (mg/kg) wet	Mercury (mg/kg) wet
GC	South	02194098	0.50%	U	77.2	0.078		0.018		0.668	0.054
GC	South	02194099	0.50%	U	78.7	0.051	U	0.010	U	0.038	0.046
Geometric Mean						0.062		0.018		0.266	0.051
Average						0.064		0.022		0.479	0.052
Maximum						0.110		0.056		1.353	0.071
Minimum						0.051		0.010		0.038	0.040
FL	Center	02194037	0.50%	U	81.8	0.046	U	0.020		0.033	0.034
FL	Center	02194038	0.60%	U	81.1	0.047	U	0.026		0.023	0.047
FL	Center	02194041	0.50%	U	81.9	0.045	U	0.034		0.010	0.073
FL	Center	02194042	0.60%	U	81.3	0.047	U	0.009	U	0.011	0.049
FL	Center	02194043	0.50%	U	80.7	0.050		0.013		0.025	0.045
FL	Center	02194044	0.50%	U	82	0.158		0.009	U	0.032	0.041
FL	Center	02194045	0.60%	U	80.6	0.109		0.027		0.475	0.071
FL	Center	02194046	0.40%	U	80.7	0.251		0.009	U	0.058	0.138
FL	Center	02194047	0.50%	U	81.8	0.328		0.022		1.494	0.077
FL	Center	02194048	NA		82.1	0.174		0.011	U	0.156	0.070
Geometric Mean						0.094		0.016		0.058	0.060
Average						0.126		0.018		0.232	0.065
Maximum						0.328		0.034		1.494	0.138
Minimum						0.045		0.009		0.010	0.034
FL	North	02194002	0.70%	U	81.5	0.046	U	0.009	U	0.016	0.036
FL	North	02194003	0.60%	U	80.7	0.048	U	0.009	U	0.018	0.034
FL	North	02194007	0.60%	U	81.3	0.047	U	0.009	U	0.021	0.049
FL	North	02194008	0.50%	U	80.8	0.048	U	0.009	U	0.017	0.052
FL	North	02194009	0.70%	U	80.5	0.049	U	0.012		0.076	0.048
FL	North	02194010	0.70%	U	80.4	0.049	U	0.010	U	0.024	0.031
FL	North	02194017	0.60%	U	80.8	0.048	U	0.010	U	0.023	0.026
FL	North	02194018	0.80%		80.6	0.049	U	0.010	U	0.033	0.046
FL	North	02194019	0.80%	U	80.9	0.048	U	0.009	U	0.019	0.028
FL	North	02194022	0.70%	U	80.6	0.049	U	0.015		0.041	0.034
Geometric Mean						0.048		0.010		0.025	0.038
Average						0.048		0.010		0.029	0.039
Maximum						0.049		0.015		0.076	0.052
Minimum						0.046		0.009		0.016	0.026

Table A-2. Coeur d'Alene Lake Analytical Results for Bullhead Samples

Sample Type	Collection Location	Sample Number	Percent Lipid (%)	Q	Moisture (%)	Arsenic (mg/kg) wet	Q	Cadmium (mg/kg) wet	Q	Lead (mg/kg) wet	Mercury (mg/kg) wet
FL	South	02194100	0.40%	U	79.4	0.052	U	0.010	U	0.011	0.072
FL	South	02194101	0.40%	U	80.9	0.048	U	0.010	U	0.080	0.065
FL	South	02194102	0.60%	U	79.7	0.051	U	0.010	U	0.028	0.068
FL	South	02194103	0.50%	U	80.5	0.049	U	0.010	U	0.011	0.068
FL	South	02194104	0.70%	U	79.4	0.052	U	0.011	U	0.045	0.053
FL	South	02194105	0.60%	U	80.4	0.051		0.010	U	0.027	0.064
FL	South	02194106	0.60%	U	81	0.048	U	0.009	U	0.010	0.065
FL	South	02194107	0.60%	U	80.1	0.050	U	0.010	U	0.017	0.057
FL	South	02194108	0.70%	U	81	0.048	U	0.010	U	0.018	0.059
FL	South	02194109	0.60%	U	79.5	0.051	U	0.010	U	0.013	0.061
Geometric Mean						0.050		0.010		0.020	0.063
Average						0.050		0.010		0.026	0.063
Maximum						0.052		0.011		0.080	0.072
Minimum						0.048		0.009		0.010	0.053

Notes:
FL - fillet; GC - gutted carcass
mg/kg - milligram per kilogram
% - percent
Q - validation qualifier

Appendix B: Summary of As, Cd, Pb, and Hg Results for Fish Samples Collected from Lake Coeur d'Alene in 2002 (mg/kg, wet weight)

Bass Gutted Carcass

Entire Lake Coeur d'Alene	**Arsenic (As)**	**Cadmium (Cd)**	**Lead (Pb)**	**Mercury (Hg)**
Total Number of Samples	30	30	30	30
Number of Detects	28	14	25	30
Maximum Concentration (mg/kg wet)	0.235	0.067	0.467	0.357
Median Concentration (mg/kg wet)	0.126	0.0065	0.105	0.124
Mean Concentration (mg/kg wet)	0.129	0.0146	0.129	0.152
Standard Deviation of the Mean	0.0552	0.0139	0.124	0.0755
Standard Error of the Mean	0.0101	0.00254	0.0226	0.0138
Coefficient of Variation of the Mean	0.428	0.954	0.959	0.496
Upper 95% CL of the Mean (mg/kg wet)	0.149	0.0197	0.175	0.18
Lower 95% CL of the Mean (mg/kg wet)	0.108	0.00936	0.0828	0.124
North Lake Coeur d'Alene	**Arsenic**	**Cadmium**	**Lead**	**Mercury**
Total Number of Samples	10	10	10	10
Number of Detects	9	8	10	10
Maximum Concentration (mg/kg wet)	0.215	0.044	0.467	0.357
Median Concentration (mg/kg wet)	0.121	0.021	0.12	0.126
Mean Concentration (mg/kg wet)	0.126	0.0209	0.156	0.174
Standard Deviation of the Mean	0.0648	0.0122	0.145	0.0992
Standard Error of the Mean	0.0205	0.00387	0.0458	0.0314
Coefficient of Variation of the Mean	0.513	0.587	0.927	0.571
Upper 95% CL of the Mean (mg/kg wet)	0.173	0.0296	0.26	0.245
Lower 95% CL of the Mean (mg/kg wet)	0.0799	0.0121	0.0526	0.103
Center Lake Coeur d'Alene	**Arsenic**	**Cadmium**	**Lead**	**Mercury**
Total Number of Samples	10	10	10	10
Number of Detects	9	2	10	10
Maximum Concentration (mg/kg wet)	0.211	0.017	0.334	0.341
Median Concentration (mg/kg wet)	0.116	0.006	0.209	0.145
Mean Concentration (mg/kg wet)	0.115	0.00765	0.197	0.171
Standard Deviation of the Mean	0.0477	0.00431	0.101	0.0704
Standard Error of the Mean	0.0151	0.00136	0.0321	0.0223
Coefficient of Variation of the Mean	0.416	0.564	0.516	0.411
Upper 95% CL of the Mean (mg/kg wet)	0.149	0.0107	0.269	0.221
Lower 95% CL of the Mean (mg/kg wet)	0.0807	0.00456	0.124	0.121
South Lake Coeur d'Alene	**Arsenic**	**Cadmium**	**Lead**	**Mercury**
Total Number of Samples	10	10	10	10
Number of Detects	10	4	5	10
Maximum Concentration (mg/kg wet)	0.235	0.067	0.153	0.17
Median Concentration (mg/kg wet)	0.146	0.00625	0.00875	0.11
Mean Concentration (mg/kg wet)	0.146	0.0152	0.0342	0.111
Standard Deviation of the Mean	0.053	0.0189	0.0463	0.0281
Standard Error of the Mean	0.0167	0.00596	0.0146	0.0089
Coefficient of Variation of the Mean	0.364	1.24	1.36	0.253
Upper 95% CL of the Mean (mg/kg wet)	0.183	0.0286	0.0673	0.132
Lower 95% CL of the Mean (mg/kg wet)	0.108	0.00167	0.00103	0.0913

Appendix B: Summary of As, Cd, Pb, and Hg Results for Fish Samples Collected from Lake Coeur d'Alene in 2002 (mg/kg, wet weight)

Bass Fillets

Entire Lake Coeur d'Alene	Arsenic (As)	Cadmium (Cd)	Lead (Pb)	Mercury (Hg)
Total Number of Samples	10	10	10	10
Number of Detects	7	1	8	10
Maximum Concentration (mg/kg wet)	0.115	0.108	0.047	0.386
Median Concentration (mg/kg wet)	0.058	0.005	0.019	0.151
Mean Concentration (mg/kg wet)	0.0639	0.0151	0.0198	0.188
Standard Deviation of the Mean	0.0343	0.0327	0.0122	0.0823
Standard Error of the Mean	0.0109	0.0103	0.00386	0.026
Coefficient of Variation of the Mean	0.537	2.17	0.618	0.439
Upper 95% CL of the Mean (mg/kg wet)	0.0884	0.0384	0.0285	0.246
Lower 95% CL of the Mean (mg/kg wet)	0.0393	-0.0083	0.011	0.129

Kokanee Gutted Carcass

Entire Lake Coeur d'Alene	Arsenic (As)	Cadmium (Cd)	Lead (Pb)	Mercury (Hg)
Total Number of Samples	11	11	11	11
Number of Detects	11	11	11	11
Maximum Concentration (mg/kg wet)	0.194	0.205	0.2	0.0853
Median Concentration (mg/kg wet)	0.14	0.123	0.104	0.0734
Mean Concentration (mg/kg wet)	0.145	0.139	0.115	0.0752
Standard Deviation of the Mean	0.0272	0.0296	0.0449	0.00576
Standard Error of the Mean	0.00819	0.00892	0.0135	0.00174
Coefficient of Variation of the Mean	0.187	0.213	0.39	0.0766
Upper 95% CL of the Mean (mg/kg wet)	0.163	0.159	0.145	0.079
Lower 95% CL of the Mean (mg/kg wet)	0.127	0.119	0.0848	0.0713

Kokanee Fillets

Entire Lake Coeur d'Alene	Arsenic (As)	Cadmium (Cd)	Lead (Pb)	Mercury (Hg)
Total Number of Samples	10	10	10	10
Number of Detects	10	8	9	10
Maximum Concentration (mg/kg wet)	0.117	0.029	0.046	0.104
Median Concentration (mg/kg wet)	0.0815	0.019	0.017	0.0939
Mean Concentration (mg/kg wet)	0.0831	0.0177	0.0203	0.0917
Standard Deviation of the Mean	0.0198	0.00698	0.0119	0.00846
Standard Error of the Mean	0.00626	0.00221	0.00376	0.00268
Coefficient of Variation of the Mean	0.238	0.394	0.586	0.0922
Upper 95% CL of the Mean (mg/kg wet)	0.0973	0.0227	0.0288	0.0978
Lower 95% CL of the Mean (mg/kg wet)	0.0689	0.0127	0.0118	0.0857

Appendix B: Summary of As, Cd, Pb, and Hg Results for Fish Samples Collected from Lake Coeur d'Alene in 2002 (mg/kg, wet weight)

Bullhead Gutted Carcass

Entire Lake Coeur d'Alene	Arsenic (As)	Cadmium (Cd)	Lead (Pb)	Mercury (Hg)
Total Number of Samples	30	30	30	30
Number of Detects	22	26	30	30
Maximum Concentration (mg/kg wet)	0.511	0.164	14.12	0.0752
Median Concentration (mg/kg wet)	0.0655	0.031	0.802	0.043
Mean Concentration (mg/kg wet)	0.113	0.0436	1.92	0.0417
Standard Deviation of the Mean	0.136	0.038	2.88	0.0149
Standard Error of the Mean	0.0248	0.00694	0.526	0.00272
Coefficient of Variation of the Mean	1.2	0.872	1.5	0.357
Upper 95% CL of the Mean (mg/kg wet)	0.164	0.0578	2.99	0.0473
Lower 95% CL of the Mean (mg/kg wet)	0.0625	0.0294	0.841	0.0361
North Lake Coeur d'Alene	**Arsenic**	**Cadmium**	**Lead**	**Mercury**
Total Number of Samples	10	10	10	10
Number of Detects	9	10	10	10
Maximum Concentration (mg/kg wet)	0.099	0.056	3.696	0.0512
Median Concentration (mg/kg wet)	0.0745	0.031	1.09	0.0254
Mean Concentration (mg/kg wet)	0.0715	0.0342	1.42	0.0283
Standard Deviation of the Mean	0.0225	0.011	1	0.0107
Standard Error of the Mean	0.00711	0.00348	0.317	0.00337
Coefficient of Variation of the Mean	0.315	0.322	0.705	0.377
Upper 95% CL of the Mean (mg/kg wet)	0.0876	0.0421	2.14	0.0359
Lower 95% CL of the Mean (mg/kg wet)	0.0554	0.0263	0.705	0.0206
Center Lake Coeur d'Alene	**Arsenic**	**Cadmium**	**Lead**	**Mercury**
Total Number of Samples	10	10	10	10
Number of Detects	8	10	10	10
Maximum Concentration (mg/kg wet)	0.511	0.164	14.12	0.0752
Median Concentration (mg/kg wet)	0.159	0.079	3.41	0.042
Mean Concentration (mg/kg wet)	0.218	0.0771	3.85	0.0451
Standard Deviation of the Mean	0.199	0.0468	4.33	0.0143
Standard Error of the Mean	0.0631	0.0148	1.37	0.00453
Coefficient of Variation of the Mean	0.915	0.606	1.13	0.318
Upper 95% CL of the Mean (mg/kg wet)	0.361	0.111	6.95	0.0553
Lower 95% CL of the Mean (mg/kg wet)	0.0754	0.0437	0.75	0.0348
South Lake Coeur d'Alene	**Arsenic**	**Cadmium**	**Lead**	**Mercury**
Total Number of Samples	10	10	10	10
Number of Detects	5	6	10	10
Maximum Concentration (mg/kg wet)	0.11	0.056	1.353	0.0708
Median Concentration (mg/kg wet)	0.0403	0.015	0.287	0.0511
Mean Concentration (mg/kg wet)	0.0503	0.0195	0.479	0.0518
Standard Deviation of the Mean	0.0285	0.0188	0.48	0.00836
Standard Error of the Mean	0.00902	0.00594	0.152	0.00264
Coefficient of Variation of the Mean	0.567	0.966	1	0.162
Upper 95% CL of the Mean (mg/kg wet)	0.0706	0.0329	0.822	0.0577
Lower 95% CL of the Mean (mg/kg wet)	0.0299	0.00601	0.135	0.0458

Appendix B: Summary of As, Cd, Pb, and Hg Results for Fish Samples Collected from Lake Coeur d'Alene in 2002 (mg/kg, wet weight)

Bullhead Fillets

Entire Lake Coeur d'Alene	**Arsenic (As)**	**Cadmium (Cd)**	**Lead (Pb)**	**Mercury (Hg)**
Total Number of Samples	30	30	30	30
Number of Detects	7	8	30	30
Maximum Concentration (mg/kg wet)	0.328	0.034	1.494	0.138
Median Concentration (mg/kg wet)	0.0245	0.005	0.0235	0.0523
Mean Concentration (mg/kg wet)	0.056	0.00918	0.0955	0.0554
Standard Deviation of the Mean	0.0748	0.00824	0.278	0.0215
Standard Error of the Mean	0.0137	0.00151	0.0507	0.00393
Coefficient of Variation of the Mean	1.34	0.898	2.91	0.389
Upper 95% CL of the Mean (mg/kg wet)	0.0839	0.0123	0.199	0.0635
Lower 95% CL of the Mean (mg/kg wet)	0.028	0.00611	-0.0082	0.0474
North Lake Coeur d'Alene	**Arsenic**	**Cadmium**	**Lead**	**Mercury**
Total Number of Samples	10	10	10	10
Number of Detects	0	2	10	10
Maximum Concentration (mg/kg wet)	0.049 U	0.015	0.076	0.052
Median Concentration (mg/kg wet)	0.024	0.00475	0.022	0.0351
Mean Concentration (mg/kg wet)	0.0241	0.00645	0.0288	0.0385
Standard Deviation of the Mean	0.000497	0.00379	0.0183	0.00936
Standard Error of the Mean	0.000157	0.0012	0.0058	0.00296
Coefficient of Variation of the Mean	0.0207	0.587	0.637	0.243
Upper 95% CL of the Mean (mg/kg wet)	0.0244	0.00916	0.0419	0.0452
Lower 95% CL of the Mean (mg/kg wet)	0.0237	0.00374	0.0157	0.0318
Center Lake Coeur d'Alene	**Arsenic**	**Cadmium**	**Lead**	**Mercury**
Total Number of Samples	10	10	10	10
Number of Detects	6	6	10	10
Maximum Concentration (mg/kg wet)	0.328	0.034	1.494	0.138
Median Concentration (mg/kg wet)	0.0795	0.0165	0.0325	0.0593
Mean Concentration (mg/kg wet)	0.116	0.0161	0.232	0.0646
Standard Deviation of the Mean	0.109	0.0111	0.466	0.0299
Standard Error of the Mean	0.0345	0.00352	0.147	0.00946
Coefficient of Variation of the Mean	0.939	0.691	2.01	0.463
Upper 95% CL of the Mean (mg/kg wet)	0.194	0.0241	0.565	0.086
Lower 95% CL of the Mean (mg/kg wet)	0.0382	0.00815	-0.1	0.0432
South Lake Coeur d'Alene	**Arsenic**	**Cadmium**	**Lead**	**Mercury**
Total Number of Samples	10	10	10	10
Number of Detects	1	0	10	10
Maximum Concentration (mg/kg wet)	0.052	0.011	0.08	0.0721
Median Concentration (mg/kg wet)	0.0253	0.005	0.0175	0.0646
Mean Concentration (mg/kg wet)	0.0276	0.005	0.026	0.0632
Standard Deviation of the Mean	0.00828	0.000236	0.0219	0.00587
Standard Error of the Mean	0.00262	0.0000745	0.00691	0.00186
Coefficient of Variation of the Mean	0.3	0.0471	0.841	0.0929
Upper 95% CL of the Mean (mg/kg wet)	0.0335	0.00517	0.0416	0.0674
Lower 95% CL of the Mean (mg/kg wet)	0.0216	0.00483	0.0104	0.059

Appendix C. Metals Eliminated as Contaminants of Concern

Metals	Detected	Maximum Concentration (mg/kg, wet weight)	Exposure Dose (mg/kg/d)	Oral MRL (mg/kg/d)	Oral RfD (mg/kg/d)
Antimony (Sb)	No	Not Applicable	---	No	0.0004
Barium (Ba)	Yes	5.328	0.04	No	0.07
Beryllium (Be)	No	Not Applicable	---	0.002	0.005
Chromium III (Cr)	Yes	7.566	0.058	No	1.5
Cobalt (Co)	Yes	0.078	0.0006	0.01 (I)	No
Copper (Cu)	Yes	2.009	0.002	0.02 (A)	No
Manganese (Mn)	Yes	17.917	0.138	No	0.14
Molybdenum (Mo)	Yes	0.152	0.001	No	0.005
Nickel (Ni)	Yes	3.493	0.027	No	0.02
Silver (Ag)	Yes	0.243	0.002	No	0.005
Selenium (Se)	Yes	0.748	0.006	0.005	0.005
Thallium (Tl)	No	Not Applicable	---	No	0.0008
Vanadium (V)	Yes	0.206	0.002	0.003 (I)	0.009
Zinc (Zn)	Yes	35.956	0.277	0.300	0.300

Maximum values are from Table A-2, USEPA (2003). MRLs are from the ATSDR internet site (http://www.atsdr.cdc.gov/mrls.html). Chronic oral MRLs are shown unless noted with an A (acute) or I (intermediate). Chronic oral RfDs are from the USEPA Integrated Risk Information System (IRIS) internet site (http://www.epa.gov/iris/). There are no FDA action levels for these metals in fish.

Chromium was assumed to be 100% trivalent (Cr III) because available literature indicates this is the form most likely to be present in fish. For thallium, the RfDs for thallium chloride and thallium sulfate are shown. For vanadium, the RfD for vanadium pentoxide is shown.

Screening exposure doses for adults were calculated using the maximum metal concentration reported, an ingestion rate of 0.540 kg/day (traditional subsistence fish consumer), an annual exposure factor of 1 (365 days per year), an absorption factor of 1 (100%), and a body weight of 70 kg. Bioavailability was assumed to be 100%. In most cases, the maximum estimated exposure dose did not surpass the applicable MRL or RfD. and were not given further consideration in this consultation. Estimated adult exposure doses for Ni and Se were in the same concentration range, but slightly (1.2-1.3 times) greater than the respective MRL. Repeating screening exposure dose calculations for nickel and selenium using an ingestion rate of 0.170 kg/day and a body weight of 35 kg (for children) indicated that conservative exposure dose estimates for children were below the MRL or the RfD.

USEPA’s IRIS web site lists the cancer classification as unknown or D (unclassifiable) for these metals.

USEPA has developed a screening level of 1.5 mg/kg for selenium (USEPA 2001). For fish with selenium levels ≤1.5 mg/kg, the monthly consumption limit is unrestricted (meaning more than 16 eight-oz. meals per month). The monthly consumption limit decreases to 12 meals/month when selenium levels are between 1.5 and 2.9 mg/kg. Selenium values in Lake Coeur d’Alene fish samples were below, or within, the range of those found in the upper Blackfoot River watershed where no fish consumption restriction exists (IDOH 2003).

Appendix D
Toxicity Information for Arsenic, Cadmium, Lead, and Mercury

Arsenic (ATSDR 2000b)

ATSDR has established a provisional acute oral minimal risk level (MRL) for arsenic at 0.005 mg/kg/day. The acute LOAEL is 0.05 mg/kg/day. This dose is associated with edema of the face, and gastrointestinal and upper respiratory symptoms, skin lesions and hepatic dysfunction, abnormal electrocardiograms, and ocular lesions. No intermediate exposure duration oral MRLs have been established. The chronic exposure duration oral MRL is 0.0003 mg/kg/day. The human chronic no-observed-adverse-effect-level (NOAEL) is 0.0008 mg/kg/day.

EPA classifies arsenic as a Class A known human carcinogen by the oral and inhalation routes. Epidemiologic studies of people exposed to arsenic in Taiwan indicate that exposure to arsenic is associated with skin cancer. Based on that and other studies, USEPA considers arsenic to be a human carcinogen. USEPA has calculated a cancer unit risk factor, 1.5 $(mg/kg/day)^{-1}$, which can be used to estimate the probability of excess risk for a lifetime of exposure to arsenic. Cancer risk was estimated based on the maximum concentration of arsenic in the contaminated surface soils at each of the locations. The cancer effect level (CEL) for arsenic in humans is 0.0011 mg/kg/day which is associated with lung cancer.

No studies were found regarding populations unusually sensitive to arsenic. Since arsenic toxicity may be influenced by the rate and extent of methylation in the liver, some population might be especially susceptible because of lower methylating capacity. This reduced capacity could result from dietary deficiency of methyl donors (choline or methionine). Liver disease does not appear to decrease methylation capacity in humans for low levels of arsenic exposure.

Cadmium (ATSDR 1999b)

MRLs for acute and intermediate exposures have not been established. ATSDR has established a chronic oral MRL (0.0002 mg/kg/day) for cadmium. The NOAEL for humans is 0.0021 mg/kg/day. Doses exceeding this level are associated with symptoms such as protein in the urine.

Cadmium is classified by EPA as a probable human carcinogen based on epidemiological studies of humans. These studies indicate that cadmium may be a carcinogen when inhaled, with the resulting condition being lung cancer. These conditions occurred in occupational settings at concentrations which are generally higher than those found in the outdoors environment.

Lead (ATSDR 1999c)

ATSDR has no MRL and EPA has no RfD for lead. Exposure to lead can cause a wide range of effects. The lack of a clear threshold for health effects and the need to consider multi-media routes of exposure makes evaluating the risks from exposure to lead in the environment difficult. Blood lead concentrations are a good measure of recent exposure, and also correlate well with health effects. Children are especially sensitive to lead, and many of its effects are observed at lower concentrations in children than in adults. Levels of 10 μg/dL, and perhaps lower in children’s blood, have been associated with decreased IQ, impaired hearing and growth, and neurobehavioral effects. The neurological effects have been shown to persist after exposure has ceased and blood lead levels have returned to normal.

Other reported neurological effects include poor memory, difficulty reading and concentrating, depression, and sleep disturbances. Lead can significantly affect both the reproductive process and the development of the fetus in women with blood lead levels as low as 10 μg/dL. Effects include premature birth and low birth weight. In adults levels as low as 15 μg/dL are linked to increased blood pressure, reduced production of sperm, earlier onset of menopause, and inhibition of enzymes responsible for the production of hemoglobin.

The increased vulnerability of children results from a combination of factors, including:

1) the increased susceptibility of developing nervous system to neurotoxic effects of lead,
2) a higher average rate of soil/dust ingestion among children,
3) the greater efficiency of lead absorption in the gastrointestinal tract of children,
4) a greater prevalence of iron or calcium deficiencies (can increase absorption of lead), and
5) the ready transfer of lead across the placenta to the developing fetus.

Foods such as fruits, grains, meat, seafood, soft drinks, vegetables and wine may contain lead. Cigarettes also contain small amounts of lead. More than 99% of all drinking water contains less than 0.005 milligrams of lead per liter. However the amount of lead taken into the body through drinking water can be higher in communities with acidic water supplies. Children residing in older dwellings may be exposed to lead by eating lead-based paint chips from peeling surfaces. The normal wear of lead-based point surfaces such as that which might occur raising and lowering windows, can lead to the creation of lead dust which can also be ingested by small children during normal hand-to-mouth activities. Lead-based paint is particularly a problem in lower income communities. For occupationally exposed individuals the usual route of exposure is through the inhalation of lead particles.

Lead is classified by EPA as a Class B2 probable human carcinogen based on animal studies. This means that there is inadequate evidence to determine lead’s carcinogenicity in humans. The National Toxicology Program (NTP) classifies lead phosphate and lead acetate as Group 2 carcinogens (probable human carcinogens).

Studies regarding exposure to lead and possible adverse health effects are discussed more extensively in the public health implications section of this document.

Mercury (ATSDR 1999a)

ATSDR has developed a chronic oral MRL for methyl mercury (0.0003 mg/kg/day). The RfD for methyl mercury is 0.0001 mg/kg/day. NOAEL for methyl mercury is 0.0013 mg/kg/day. The FDA has established an action level of one mg/kg for methyl mercury in fish.

Methyl mercury is the form of mercury most easily absorbed through the gastrointestinal tract (about 95% absorbed). Exposure to methyl mercury can come from foods contaminated with mercury on the surface (for example, from seed grain treated with methyl mercury to kill fungus) or from foods that contain toxic levels of methyl mercury (as in some fish, wild game, and marine mammals). Mothers who are exposed to methyl mercury and breast-feed their infant may also expose the child through the milk.

Critical periods of neonatal development and the early months after birth are times that are particularly sensitive to the harmful effects of methyl mercury on the nervous system. Exposure to methyl mercury is more dangerous for young children than for adults because methyl mercury more easily passes into the developing brain of young children and may interfere with the development process. Methyl mercury can accumulate in fetal blood to concentrations higher than in the mother. Abnormal heart rhythms have been seen in children who ate grains contaminated with very high levels of methyl mercury. Methyl mercury that enters the body can be converted to inorganic mercury and result in kidney damage.

Individuals with diseases of the liver, kidneys, lungs, and nerves are considered to be at a greater risk of suffering from the toxic effects of organic mercury. Individuals with a dietary insufficiency of zinc, glutathione, antioxidants, or selenium or those who are malnourished may be more susceptible to the toxic effects of mercury poisoning because of the diminished ability of these substances to protect against mercury toxicity.

Appendix E

Limited Fish Meals Calculated by the State of Idaho Based on Bass, Bullhead and Kokanee Samples Collected from Lake Coeur d'Alene in 2002

Table 1. Limited Fish Meals Per Month for Bass

Sample Type, Location	Chemical	Concentrations (mg/kg wet)		Meals Per Month*		
		Range	Arithmetic Mean	General (8 oz)	Pregnant Women (8 oz)	Children (4 oz)
GC (North)	Mercury	0.075-0.357	0.174	NA	5.4	3.1
	Arsenic	0.034 (U)-0.215	0.126	13.3	11.6	6.6
	Lead	0.01-0.467	0.156	185	40	25
	Cadmium	0.006 (U)-0.044	0.0209	514	450	257
	Zinc	12.686-24.227	17.4	185	162	93
	Lowest Meals			13	5	3
GC (Center)	Mercury	0.108-0.341	0.171	NA	5.5	3.1
	Arsenic	0.062 (U)-0.211	0.115	14.5	12.7	7.3
	Lead	0.035-0.334	0.197	146	32	20
	Cadmium	0.006 (U)-0.017	0.00765	1403	1228	702
	Zinc	8.821-14.672	12.3	262	229	131
	Lowest Meals			15	6	3
GC (South)	Mercury	0.0635-0.17	0.111	NA	8.5	4.8
	Arsenic	0.073-0.235	0.146	11.4	10.0	5.7
	Lead	0.011-0.153	0.0342	843	183	>26
	Cadmium	0.012 (U)-0.067	0.0152	706	618	353
	Zinc	10.663-19.302	13.5	238	209	119
	Lowest Meals			11	9	5
FL (Center)	Mercury	0.121-0.386	0.188	NA	5.0	2.9
	Arsenic	0.048 (U)-0.115	0.0639	26.1	22.9	13.1
	Lead	0.009 (U)-0.047	0.0198	1456	316	>26
	Cadmium	0.005 (U)-0.108	0.0151	711	622	356
	Zinc	3.302-5.744	4.87	661	579	331
	Lowest Meals			26	5	3

- Meal Size: 8 oz for general population and women of childbearing age, 4 oz for children under seven
- >26: more than 26 meals per month
- NA: there is no methyl mercury RfD for general population to calculated the corresponding limited meals.

Table 2. Limited Fish Meals Per Month for Bullhead

Sample Type, Location	Chemical	Concentrations (mg/kg wet)		Meals Per Month*		
		Range	Arithmetic Mean	General (8 oz)	Pregnant Women (8 oz)	Children (4 oz)
GC (North)	Mercury	0.0172-0.0512	0.0283	NA	33.2	19
	Arsenic	0.048 (U)-0.099	0.0715	23.4	20.4	11.7
	Lead	0.517-3.696	1.42	20.3	4.4	2.7
	Cadmium	0.02-0.056	0.0342	314	275	157
	Zinc	15.299-22.422	17.9	180	157	90
	Lowest Meals			20	4	3
GC (Center)	Mercury	0.0246-0.0752	0.0451	NA	20.8	11.9
	Arsenic	0.046 (U)-0.511	0.218	7.7	6.7	3.8
	Lead	0.07-14.12	3.85	7.5	1.6	0
	Cadmium	0.009-0.164	0.0771	139	122	70
	Zinc	10.328-39.956	19.7	164	143	82
	Lowest Meals			8	2	0
GC (South)	Mercury	0.0398-0.0708	0.0518		18.1	10.4
	Arsenic	0.051 (U)-0.11	0.0503	33.2	29.1	16.6
	Lead	0.038-1.353	0.479	60.2	13	8
	Cadmium	0.01 (U)-0.056	0.0195	551	482	275
	Zinc	12.738-19.907	14.8	218	190	109
	Lowest Meals			33	13	8
FL (North)	Mercury	0.0263-0.052	0.0385	NA	24.4	13.9
	Arsenic	0.046 (U)-0.049	0.0241	69	61	35
	Lead	0.016-0.076	0.0288	1001	217	>26
	Cadmium	0.009 (U)-0.015	0.00645	1665	1457	832
	Zinc	4.792-6.215	5.52	584	511	292
	Lowest Meals			69	24	14
FL (Center)	Mercury	0.0344-0.138	0.0646	NA	14.5	8.3
	Arsenic	0.045 (U)-0.328	0.116	14.4	12.6	7.2
	Lead	0.01-1.494	0.232	124	27	16.8
	Cadmium	0.009 (U)-0.034	0.0161	667	584	333
	Zinc	4.199-7.171	5.29	609	533	304
	Lowest Meals			14	13	7
FL (South)	Mercury	0.0526-0.0721	0.0632	NA	14.9	8.5
	Arsenic	0.048 (U)-0.052	0.0276	61	53	30
	Lead	0.010-0.080	0.026	1109	241	>26
	Cadmium	0.009(U)-0.011(U)	0.005	2147	1879	1073
	Zinc	4.522-5.335	5.03	640	560	320
	Lowest Meals			61	15	9

- Meal Size: 8 oz for general population and women of childbearing age, 4 oz for children under seven
- >26: more than 26 meals per month
- NA: there is no methyl mercury RfD for general population to calculated the corresponding limited meals.

Table 3. Limited Fish Meals Per Month for Kokanee

Sample Type, Location	Chemical	Concentrations (mg/kg wet)		Meals Per Month*		
		Range	Arithmetic Mean	General (8 oz)	Pregnant Women (8 oz)	Children (4 oz)
GC (Whole Lake)	Mercury	0.067-0.0853	0.0752	NA	12.5	7.1
	Arsenic	0.105-0.194	0.145	11.5	10.1	5.8
	Lead	0.061-0.2	0.115	251	54	>26
	Cadmium	0.112-0.205	0.139	77	68	39
	Zinc	17.292-27.361	20	161	141	81
	Lowest Meals			12	10	6
FL (Whole Lake)	Mercury	0.0787-0.104	0.0917	NA	10.2	5.9
	Arsenic	0.051-0.117	0.0831	20.1	17.6	10
	Lead	0.011 (U)-0.046	0.0203	1420	308	>26
	Cadmium	0.012 (U)-0.029	0.0177	607	531	303
	Zinc	5.628-10.746	7.05	457	400	228
	Lowest Meals			20	10	6

- Meal Size: 8 oz for general population and women of childbearing age, 4 oz for children under seven
- >26: more than 26 meals per month
- NA: there is no methyl mercury RfD for general population to calculated the corresponding limited meals.

Appendix F. Joint Fish Consumption Advisory Issued by the State of Idaho and the Coeur d'Alene Tribe

IDAHO DEPARTMENT OF

HEALTH & WELFARE

DIRK KEMPTHORNE – Governor

KARL B. KURTZ – Director
450 West State, 10th Floor
P.O. Box 83720
Boise, ID 83720-0036
PHONE 208-334-5500
FAX 208-334-6558

JOINT ADVISORY

Lake Coeur d'Alene Fish Advisory 2003

Fish were collected from Lake Coeur d'Alene in May and August of 2002 as described in the *Coeur d'Alene Lake Fish Investigation Plan* (USEPA 2002a), and were analyzed for metals (mercury, arsenic, lead, cadmium and zinc) to determine if the fish are safe for consumption by members of the general public and the Coeur d' Alene Tribe. Sampling locations in the Lake are shown in Figure 1. The results of the laboratory analysis of the fish samples are provided in the *Coeur d'Alene Lake Fish Investigation Data Report* (USEPA 2003).

Based on extensive discussions among scientists and interested parties, kokanee (*Oncorhynchus nerka*), Bass (mostly largemouth bass, *Micropterus salmoides*), and bullhead (mostly brown bullhead, *Ameirus nebulosus*) were selected as the target species because of their use by both tribal and sport/recreational fishers. All three species are extensively used by tribal subsistence fishers. Notably, the three species are also of ecological importance to the Lake Coeur d'Alene fishery and encompass a variety of feeding habits and exposure patterns to contaminants.

Kokanee are primarily planktivorous, feeding on microscopic plants and animals in the water column, whereas largemouth bass are predatory on other fish. Kokanee range throughout the Lake, whereas bass are lurking predators with a relatively small home range compared to kokanee. The large home range of kokanee means that they should serve as a good indicator of contaminant concentrations throughout Lake Coeur d'Alene. Largemouth bass, which prey on other fish and have a smaller home range, should be more indicative of contaminant concentrations in localized areas of the Lake. Some smallmouth bass were also collected during the field effort. Bullheads are mostly bottom feeders and are normally closely associated with bottom sediments.

The tissue types analyzed were intended to be representative of two of the major methods by which fish caught in Lake Coeur d'Alene are prepared for consumption by subsistence and sport/recreational fishers, i.e. gutted whole fish and fillets. The gutted whole fish tissue type consisted of remaining tissue after the removal of the caudal (tail) fin, gills, and guts with the exception of the kidney. The gutted whole fish carcass tissue sample was intended to represent the most commonly used preparation method for fish that are smoked, canned, and that are used in soups or stews. Fillets are commonly consumed by tribal, sport and recreational fishers.

Data collected indicate that mercury, lead and arsenic are the three contaminants with high enough concentrations in fish tissue to warrant a fish advisory. Table 1 shows the species-specific, limited meal (the amounts of fish the Idaho Fish Consumption Advisory Program [IFCAP] considers safe to consume) advisory. Where applicable, species-specific consumption rates are given for sections of the Lake as opposed to a blanket statement about the entire Lake.

Table 1. The Species-specific, Limited Meal Advisory

Species	Sample Type	Location	Consumption Advisory (meals per month)			Contaminant of Concern
			General Population (8 oz. meal)	**Pregnant Women[a] (8 oz. meal)**	**Children[b] (4 oz. meal)**	
Bass	**Gutted Whole Fish**	**North**	13	5	3	Arsenic: general population Mercury: pregnant women & children
		Center	15	6	3	
		South	11	9	5	
	Fillet	**Whole Lake**	26	5	3	
Bullhead[c]	**Gutted Whole Fish**	**North**	20	4	3	Lead
		Center	8	2	0	
		South	33	13	8	
	Fillet	**North**	69	24	14	Arsenic: general population Mercury: pregnant women & children
		Center	14	13	7	Arsenic
		South	61	15	9	Arsenic: general population Mercury: pregnant women & children
Kokanee	**Gutted Whole Fish**	**Whole Lake**	12	10	6	Arsenic
	Fillet		20	10	6	Arsenic: general population Mercury: pregnant women & children

a: Pregnant women, women planning to be pregnant, and nursing mothers.
b: Children 6 years old or younger.
c: People, especially children and pregnant women with increased blood lead levels, or living in an area with high concentrations of lead in the yard soil or house dust should eat less whole Bullhead than suggested in this advisory.

Due to the limited resources, only three representative fish species were sampled from Lake Coeur d'Alene as discussed above. Per Charles Corsi and Ned Horner (Idaho Department of Fish and Game), other fish species regularly caught in Lake Coeur d'Alene could be grouped according to behavior similarity to one of the three sampled species (bass, kokanee and bullhead) IFCAP currently has data for:

- Predators: **bass** (largemouth and smallmouth), northern pike, chinook salmon (a pelagic predator feeding primarily on kokanee), Large (over 8 inches) crappie and perch, and northern pikeminnow.
- Filter feeder/insectivore: k**okanee**, bluegill, smaller perch and crappie, pumpkinseed, cutthroat trout (no cutthroat trout between 8 inches and 16 inches long may be kept), rainbow trout, tench, and brook trout.
- Bottom feeder: **bullhead** (mostly brown bullhead), channel catfish, and suckers.

Although there are no fish tissue metal data for fish species other than bass, bullhead and kokanee, IFCAP believes the metal concentrations in the same group of fish species should be similar. Therefore, IFCAP suggests people compare the game fish they catch to the appropriate species group (bass, bullhead, and kokanee) and limit their consumption accordingly. For instance, IFCAP suggests that children limit their consumption of bluegill to 6 meals per month, the same as kokanee.

Other Basic Information

This fish advisory delineates how much and which type of fish can be safely consumed from Lake Coeur d'Alene, and which populations are most affected by the advisory. An issued fish advisory does not mean that people should stop eating fish from the Lake. In fact, metals found in fish from the Lake are lower than metals found in some fish purchased from the grocery such as shark, swordfish, and tuna. There is no need to substitute grocery store purchased fish for Lake-caught fish. By following the advisory, it is unlikely any ill effects will result from eating the fish caught from Lake Coeur d'Alene. This fish advisory is not mandatory and is issued only as a precaution in the interests of public health and safety.

In general, consuming smaller, younger fish (within Tribal and State legal limits) and those lower on the food chain is advised because these fish tend to be less contaminated. Also, insectivores and filter feeders may be preferable to bottom feeders since they do not contact sediment as much as bottom feeders.

Future Actions

Bass, bullhead and kokanee were sampled and analyzed for mercury, arsenic, lead, cadmium and zinc concentrations in the edible tissue. Mercury, lead and arsenic are the three contaminants with high enough concentrations in fish tissue to warrant a fish advisory.

Because the fish samples from Lake Coeur d'Alene fulfill the IFCAP sampling protocols (more than 10 fish per species per sampling location), a formal fish advisory has been issued. The governments involved in the Lake Coeur d'Alene fish study suggest sampling more fish in the future when possible, to verify whether or not they continue to pose a public health threat.

The Idaho Department of Health and Welfare laboratory will analyze the polychlorinated biphenyl (PCB) concentrations in all the fish tissue samples. When the data are available, the governments involved in the Lake Coeur d'Alene fish study will revisit this fish advisory if warranted by the PCB levels.